PATENT ABSTRACTS OF JAPAN

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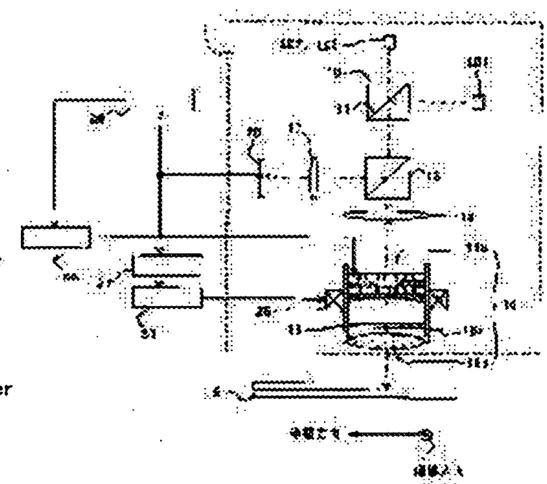
(54) OPTICAL PICKUP

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an optical pickup capable of recording and reproducing data in optical disks or recording surfaces different in corresponding wavelength and suitable to miniaturization.
SOLUTION: This optical pickup is provided with a first light source of a semiconductor laser emitting a first light beam having a first wavelength, a second light source of a semiconductor laser emitting a second light beam having a second wavelength longer than the first wavelength, a third light source of a semiconductor emitting a third light beam having a third wavelength longer than the second wavelength, an optical axis coupling element making the optical paths of the first, second and third light beams in common and a condenser lens for condensing the first, second and third light beams on the information recording surface of a recording medium. The optical head is provided with a diffraction optical device which is arranged in the optical paths from the first, second and third optical sources to the condenser lens and moreover includes a diffraction grating having a rotation symmetric central axis arranged at the center of the optical path. The diffraction grating is provided with a cross section shape which condenses diffracted light whose absolute value is first or more order as information reading light or information recording light with respect to the first and second light beam and which condenses diffracted light of zeroth order as information reading light or information recording light with respect to the third light beam via the condenser lens.



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CLAIMS

[Claim(s)]
[Claim 1] The 1st light source of the semiconductor laser which carries out outgoing radiation of the 1st light beam which has the 1st wave, The 2nd light source of the semiconductor laser which carries out outgoing radiation of the 2nd light beam which has the 2nd wave longer than the 1st wave, The 3rd light source of the semiconductor laser which carries out outgoing radiation of the 3rd light beam which has the 3rd wave longer than the 2nd wave, The optical-axis joint component which makes the optical path of said 1st, 2nd, and 3rd light beams communalize, The condenser lens which makes the information recording surface of a record medium condense said 1st, 2nd, and 3rd light beams, It has a diffracted-light study component containing the diffraction grating which has the symmetry-of-revolution medial axis which was preparation ****************, has been arranged in the optical path from said 1st, 2nd, and 3rd light sources to said condenser lens, and has been arranged at the core of said optical path. As for said diffraction grating, about said 1st and 2nd light beams, an absolute value condenses the primary more than diffracted light as information reading light or an information record light through said condenser lens. said 3rd light beam — zero — the optical pickup characterized by having the cross-section configuration which makes the following diffracted light condense as information reading light or an information record light.
[Claim 2] The plate of translucency with which said diffracted-light study component countered parallel of a pair, and the liquid crystal layer pinched by said plate, The counterelectrode of the pair which is prepared in said monotonous inside which counters, respectively, and impresses an electrical potential difference to said liquid crystal layer, said diffraction grating monotonous and prepared on said said counterelectrode facing said liquid crystal layer — since — at least one side of the counterelectrode of said pair The central transparent electrode arranged at said symmetry-of-revolution medial axis, and the annular transparent electrode arranged the surroundings of said central transparent electrode, At the time of said 1st or 2nd light beam exposure, the same electrical potential difference is impressed to said central transparent electrode and said annular transparent electrode. since — The optical pickup according to claim 1 characterized by having an armature-voltage control means to impress an electrical potential difference which is different in said central transparent electrode and said annular transparent electrode at the time of said 3rd light beam exposure.
[Claim 3] Said diffracted-light study component is an optical pickup according to claim 2 characterized by having the plano-concave lens which makes said optical path common.
[Claim 4] It is the optical pickup according to claim 2 which said diffracted-light study component has said plano-concave lens unified as it is monotonous, and is characterized by forming said diffraction grating in the flat surface of said plano-concave lens.
[Claim 5] Said diffraction grating formed on translucency [which said diffracted-light study component becomes from an anisotropy optical material] parallel monotonous, The complementary translucency parallel plate which consists of an isotropic optical material with which said diffraction grating was filled up, It has a means to make the main plane of polarization of one light in said 1st, 2nd, and 3rd light beams incline to the main plane of polarization of other light. since — the time of said 1st or 2nd light beam exposure — effective opening — providing — and — the time of said 3rd light beam exposure — said effective opening — smallness — the optical pickup according to claim 1 characterized by having the opening control means which offers effective opening.
[Claim 6] Said diffracted-light study component is an optical pickup according to claim 5 characterized by having the plano-concave lens which turned the crevice to said condenser lens side.
[Claim 7] Said diffracted-light study component is an optical pickup according to claim 5 characterized by having the plano-concave lens which was united with said complementary translucency parallel plate by the side of said condenser lens, and turned the crevice to said condenser lens side.
[Claim 8] Said opening control means is the optical pickup of any 1 publication of claims 5-7 characterized by being a dichroic mirror.
[Claim 9] The include angle which makes the main plane of polarization of one light in said 1st, 2nd, and 3rd light beams incline to the main plane of polarization of other light is the optical pickup of any 1 publication of claims 5-8 characterized by being 90 degrees.
[Claim 10] Said anisotropy optical material is the optical pickup of any 1 publication of claims 5-9 which are uniaxial crystals and are characterized by the optical axis inclining to the direction of incidence of said 1st, 2nd, and 3rd light beams.
[Claim 11] Said diffracted-light study component is the optical pickup of any 1 publication of claims 1-10 characterized by making a concave lens operation to said 1st or 2nd light beam.
[Claim 12] Said condenser lens is the optical pickup of any 1 publication of claims 1-11 characterized by being the lens with which aberration was amended in the wavelength range of the 1st and 2nd light beams.
[Claim 13] Said diffraction grating is the optical pickup of any 1 publication of claims 1-12 characterized by condensing the 1st light beam diffracted light of the 1st order of diffraction as information reading light or an information record light about said 1st light beam, and condensing the 2nd light beam diffracted light of the 2nd order of diffraction of a low degree as information reading light or an information record light from said 1st order of diffraction about said 2nd light beam through said condenser lens.
[Claim 14] It is the optical pickup according to claim 13 characterized by said 2nd light beam diffracted light being the primary diffracted light when said 1st light beam diffracted light is the secondary diffracted light.
[Claim 15] The optical pickup of any 1 publication of claims 1-14 characterized by the cross section of said diffraction grating consisting of irregularity of serrate or a stairway configuration.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the optical pickup which makes possible compatibility from the optical disk with which correspondence wavelength differs to CD, CD-R, DVD, and HD-DVD using a laser light source of especially different wavelength about the optical system of the optical pickup in the optical recording regenerative apparatus which carries out record playback of the information.
[0002]
[Description of the Prior Art] There is an optical disk player which reads recording information and can do it from optical disks, such as an optical recording medium (compact disc), for example, CD, CD-R (compact disc rewritable), and DVD (digital video disc), in the account rec/play student equipment of optical. Although CD in recent years and the spread of CD-Rs have a remarkable thing, DVD of 4.7GB of large capacity is further introduced into the commercial scene. The demand of the package media in which high density record is still more possible is strong in a commercial scene.
[0003] It is effective in improvement in recording density to make high short-wavelength-izing of the light source and the numerical aperture (NA) of an objective lens which are used as known well. About short-wavelength-izing, research of the semiconductor laser (for example, wavelength of 405nm) of the short wavelength which used the GaN substrate as the base shows progress, and utilization has it in near level. Research of about 15GB of high density DVD (HD-DVD) system using the semiconductor laser of short wavelength is advanced similarly.
[0004] Then, it will search for, the compatibility, i.e., the compatibility, as for which recording information is read and made to the account rec/play student equipment of HD-DVD optical from CD, CD-R, and DVD. A duty of the compatible regeneration system is imposed as naturally DVD being reproducible. It becomes a problem that a two-layer disk cannot be read among DVD disks by the laser of short wavelength here. Since the reflection factor in the short wave Nagamitsu beam of the middle class of a two-layer disk is low, this is produced. Therefore, in order to realize a compatible disk player, a HD-DVD system needs to carry the laser which emits light in the light beam (only henceforth red) of the red near the wavelength of 650nm in addition to the laser which emits light in the blue light beam near the wavelength of 405nm (only henceforth blue).
[0005] Furthermore, CD-R is unreproducible near 650nm of DVD, and near 405nm of HD-DVD. It is because it falls rapidly on the other wavelength although just the reflection factor in nearly 780nm of the CD-R recording layer made in the pigment layer is high. Since a recording surface is an aluminum reflecting layer, although CD is refreshable, it needs the about 780nm light source for reproducing CD-R on other wavelength. Incidentally, in CD and CD-R, substrate thickness is 1.2mm and the numerical aperture of 780nm and an objective lens of correspondence wavelength is about 0.45. Moreover, in DVD, substrate thickness is 0.6mm and the numerical aperture of 635nm - 655nm and an objective lens of correspondence wavelength is about 0.6. In HD-DVD, substrate thickness is 0.6mm and the numerical aperture of 405nm and an objective lens of correspondence wavelength is about 0.6.
[0006] The requirements which reproduce CD-R are that aberration is amended on the wavelength near 780nm, amending the difference in disk substrate thickness, changing NA, and ******. Therefore, in order to realize a full compatible disk player, a HD-DVD system needs to carry the laser which emits light in the light beam (only henceforth red) of the red near the wavelength of 650nm in addition to the laser which emits light in the blue light beam near the wavelength of 405nm (only henceforth blue). Furthermore, it is necessary to also carry CD and the laser which emits light in the light beam (only henceforth infrared rays) of the infrared radiation near [for CD-R] the wavelength of 780nm.
[0007] However, it is difficult to condense mostly the various light from which wavelength differs with the conventional single lens for the chromatic aberration which an objective lens has by non-aberration. For this reason, in order to secure the compatibility of CD, CD-R, DVD, and HD-DVD, a certain device is needed.
[0008]
[Problem(s) to be Solved by the Invention] Then, although the approach of changing for every wavelength using an exclusive objective lens can be considered as the implementation approach of the optical pickup for the compatible players of CD, CD-R, DVD, and HD-DVD, since a complicated lens change device is required of that of ****, cost increases and an actuator becomes large about three kinds of objective lenses, it is disadvantageous for a miniaturization. Moreover, although how to combine with an objective lens and a collimator lens can be considered as other approaches, since the collimator is fixed to an objective lens, problems, like it is difficult to maintain the engine performance at the time of migration of an objective lens occur.
[0009] Anyway, in order to secure the compatibility of CD, CD-R, DVD, and HD-DVD, when the optical system of the prism of dedication, a lens, etc. is constituted using two or more light sources, there is an inclination for an optical pickup or the optical whole head to become complicated, and to become large-sized. This invention is made in view of the above-mentioned technical problem, and is to offer the optical pickup which was suitable for the miniaturization in which an account rec/play student is possible to the optical disk or recording surface from which correspondence wavelength differs.
[0010]
[The means for solving invention] The 1st light source of the semiconductor laser to which the optical pickup of this invention carries out outgoing radiation of the 1st light beam which has the 1st wave, The 2nd light source of the semiconductor laser which carries out outgoing radiation of the 2nd light beam which has the 2nd wave longer than the 1st wave, The 3rd light source of the semiconductor laser which carries out outgoing radiation of the 3rd light beam which has the 3rd wave longer than the 2nd wave, The optical-axis joint component which makes the optical path of said 1st, 2nd, and 3rd light beams communalize, The

condenser lens which makes the information recording surface of a record medium condense said 1st, 2nd, and 3rd light beams. It has a diffracted-light study component containing the diffraction grating which has the symmetry-of-revolution medial axis which was preparation ****************, has been arranged in the optical path from said 1st, 2nd, and 3rd light sources to said condenser lens, and has been arranged at the core of said optical path. As for said diffraction grating, about said 1st and 2nd light beams, an absolute value condenses the primary more than diffracted light as information reading light or an information record light through said condenser lens. said 3rd light beam -- zero -- it is characterized by having the cross-section configuration which makes the following diffracted light condense as information reading light or an information record light.

[0011] In the optical pickup of this invention said diffracted-light study component The plate of the translucency which countered parallel of a pair, and the liquid crystal layer pinched by said plate. The counterelectrode of the pair which is prepared in said monotonous inside which counters, respectively, and impresses an electrical potential difference to said liquid crystal layer, said diffraction grating monotonous and prepared on said said counterelectrode facing said liquid crystal layer -- since -- at least one side of the counterelectrode of said pair The central transparent electrode arranged at said symmetry-of-revolution medial axis, and the annular transparent electrode arranged the surroundings of said central transparent electrode, since -- it is characterized by having an armature-voltage control means to impress the same electrical potential difference to said central transparent electrode and said annular transparent electrode at the time of said 1st or 2nd light beam exposure, and to impress an electrical potential difference which is different in said central transparent electrode and said annular transparent electrode at the time of said 3rd light beam exposure.

[0012] In the optical pickup of this invention, said diffracted-light study component is characterized by having the plano-concave lens which makes the inside of said optical path common. In the optical pickup of this invention, said diffracted-light study component has said plano-concave lens unified as it is monotonous, and it is characterized by forming said diffraction grating in the flat surface of said plano-concave lens.

[0013] In the optical pickup of this invention said diffracted-light study component Said diffraction grating formed on translucency [which consists of an anisotropy optical material] parallel monotonous, The complementary translucency parallel plate which consists of an isotropic optical material with which said diffraction grating was filled up, It has a means to make the main plane of polarization of one light in said 1st, 2nd, and 3rd light beams incline to the main plane of polarization of other light. since -- the time of said 1st or 2nd light beam exposure -- effective opening -- providing -- and -- the time of said 3rd light beam exposure -- said effective opening -- smallness -- it is characterized by having the opening control means which offers effective opening.

[0014] In the optical pickup of this invention, said diffracted-light study component is characterized by having the plano-concave lens which turned the crevice to said condenser lens side. In the optical pickup of this invention, said diffracted-light study component is characterized by having the plano-concave lens which was united with said complementary translucency parallel plate by the side of said condenser lens, and turned the crevice to said condenser lens side.

[0015] In the optical pickup of this invention, it is characterized by said opening control means being a dichroic mirror. In the optical pickup of this invention, it is characterized by the include angle which makes the main plane of polarization of one light in said 1st, 2nd, and 3rd light beams incline to the main plane of polarization of other light being 90 degrees.

[0016] In the optical pickup of this invention, said anisotropy optical material is a uniaxial crystal, and it is characterized by the optical axis inclining to the direction of incidence of said 1st, 2nd, and 3rd light beams. In the optical pickup of this invention, said diffracted-light study component is characterized by making a concave lens operation to said 1st or 2nd light beam.

[0017] In the optical pickup of this invention, said condenser lens is characterized by being the lens with which aberration was amended in the wavelength range of the 1st and 2nd light beams. In the optical pickup of this invention, said diffraction grating is characterized by condensing the 1st light beam diffracted light of the 1st order of diffraction as information reading light or an information record light about said 1st light beam, and condensing the 2nd light beam diffracted light of the 2nd order of diffraction of a low degree as information reading light or an information record light from said 1st order of diffraction about said 2nd light beam through said condenser lens.

[0018] In the optical pickup of this invention, when said 1st light beam diffracted light is the secondary diffracted light, said 2nd light beam diffracted light is characterized by being the primary diffracted light. In the optical pickup of this invention, it is characterized by the cross section of said diffraction grating consisting of irregularity of serrate or a stairway configuration.

[0019]

[Function] The liquid crystal hologram used by this invention is an active component, and can perform comparatively simply the change by actuation of a seal-of-approval electrical potential difference. Moreover, the servo actuation which always maintains diffraction efficiency to max by the fine control of a seal-of-approval electrical potential difference is also possible. One polarization hologram can make it substitute for change actuation in false by making the polarization direction of laser intersect perpendicularly.

[0020]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained, referring to a drawing.

(Optical pickup) Drawing 1 shows the outline of the optical pickup of the gestalt of an example. Semiconductor laser LD1 for HD-DVD to which, as for an optical pickup, the 1st wave carries out outgoing radiation of 400nm - the 410nm of the blue of the short wavelength near 405nm preferably, Semiconductor laser LD2 for DVD which carries out outgoing radiation of the red, the 2nd wave, i.e., the medium wave length desirable 630nm - 660nm for DVD near 650nm, longer than the 1st wave, It has CD, the 3rd wave, i.e., near 780nm, CD which carries out outgoing radiation of the infrared rays of the long wavelength for CD-R, and semiconductor laser LD3 for CD-R. [longer than the 2nd wave] With the gestalt of this operation, the semiconductor laser LD2 and CD for DVD of the red for DVD and infrared semiconductor laser LD3 for DVD for CD-R use the semiconductor laser of one apparatus. Semiconductor laser LD1, LD2, and LD3 is changed as CD, the object for CD-R, the object for HD-DVD, and an object for DVD, respectively, and is turned on.

[0021] Furthermore, the optical pickup is equipped with the optical-axis joint prism (color composition prism) 10 of the optical-axis joint component which makes these 1st, 2nd, and 3rd light beams, i.e., blue, red, and an infrared optical path communalize. As shown in drawing 1 , the optical-axis joint prism 10 of this optical system is designed so that the emission light beam of semiconductor laser LD1, LD2, and LD3 may be made with a common optical path, and has the function to carry out abbreviation coincidence of the optical axis of the laser beam of three wavelength. While the dichroic mirror 11 in the optical-axis joint prism 10 reflects blue with a wavelength of 405nm, it is formed with the multilayer dielectric thin film so that it may have the property which penetrates infrared rays with a red of with a wavelength of 650nm and a wavelength of 780nm and may have a dependency whenever [incident angle]. Moreover, without being limited to optical-axis joint prism, the optical-axis joint component which

compounds an optical axis can be replaced with a dichroic mirror, and can use a diffraction grating, a liquid crystal cholesteric layer, etc. using the wavelength difference of an angle of diffraction for an optical-axis joint component.
[0022] Moreover, the optical pickup equips the lower stream of a river of the optical axis of the optical-axis joint prism 10 with the polarization beam splitter 13, the collimator lens 14, and the objective lens unit 16. The quarter-wave length plate 15 is also contained in the objective lens unit 16. Through the optical-axis joint prism 10 and a polarization beam splitter 13, it is made an parallel light beam by the collimator lens 14 by the above optical exposure optical system, and is condensed towards the optical disk 5 placed near [the] the focus by the objective lens unit 16, and the laser beam from at least one of the 1st, 2nd, and 3rd semiconductor laser LD1, LD2, and LD3 forms an optical spot on the pit train of the information recording surface of an optical disk 5 according to it. That is, since the blue, the red, and the infrared light beam from the three light sources of laser light sources LD1, LD2, and LD3 are compounded by one optical path with the optical-axis joint prism 10 as shown in drawing 1 , the objective lens unit 16 makes the blue corresponding to the recording surface top of the optical disk of either CD, CD-R, HD-DVD and DVD, red, or infrared either condense.
[0023] In addition to the above optical exposure optical system, the optical pickup has photodetection optical system, such as the detection lens 17, further, and the objective lens unit 16, the quarter-wave length plate 15, and the polarization beam splitter 13 are used also for photodetection optical system. The reflected lights from any one optical disk 5 of CD, CD-R, HD-DVD, and the DVD are collected in the objective lens unit 16, and are turned to the condenser lens 17 for detection by the polarization beam splitter 13 through the quarter-wave length plate 15. The focusing light condensed with the detection lens 17 forms an optical spot near the light-receiving side 20 core of the quadrisection photodetector which has four light-receiving sides which two segments which pass astigmatism generating components (not shown), such as a cylindrical lens and a multi-lens, for example, intersect perpendicularly come to quadrisect.
[0024] Moreover, the light-receiving side 20 of a photodetector is connected to a controller 30 and the error detection circuit 31 including a demodulator circuit. The error detection circuit 31 is connected to the drive circuit 33 which drives the device containing the actuator 26 the tracking control of an objective lens unit, and for focal control. A quadrisection photodetector supplies the electrical signal according to the optical spot image by which image formation was carried out near [the] the light-receiving side 20 core to a controller 30 and the error detection circuit 31. The demodulator circuit of a controller 30 generates a record signal based on the electrical signal. The error detection circuit 31 generates a focal error signal, a tracking error signal, other servo signals, etc. based on the electrical signal, each driving signal is supplied to each actuator through the drive circuit 33 of an actuator, and these carry out the servo control drive of the objective lens unit 16 etc. according to each driving signal. (Objective lens unit) The objective lens unit 16 is the assembly of the compound objective lens which combined condenser lens 16a which condenses a light beam to an optical disk recording surface, and diffracted-light study component 16b equipped with the liquid crystal layer which can control by the electrical and electric equipment, as shown in drawing 1 R> 1. Condenser lens 16a and diffracted-light study component 16b are arranged by holder 16c at the same axle focusing on an optical path.
[0025] The aspheric lens with which it is the blue wavelength range of 400nm - 410nm or the red wavelength range of 630nm - 660nm, or aberration was amended in the blue wavelength range at least is used for condenser lens 16a. As for condenser lens 16a, it is still more desirable to use the lens with which aberration was amended in both the wavelength range of blue and red. A reason is that tolerance in both blue wavelength is loosely made with red. Generally, since it normalizes on wavelength and tolerance becomes severe in inverse proportion to wavelength, if it compares on the wavelength of red and blue, since the direction from which the desirable property in blue wavelength is taken out will become difficult, as for aberration, it is desirable to use the aspheric lens with which aberration was especially amended in the blue wavelength range. As a condenser lens amended on both wavelength, the usual single optical glass lens is used and 2P objective lens created by 2P law using photopolymer ******** 2P is used further.
[0026] Diffracted-light study component 16b located in the optical path from the light source side 10, i.e., optical-axis joint prism, to condenser lens 16a The plates 161 and 162 of the translucency of the glass which countered parallel of a pair as shown in drawing 2 , The liquid crystal layer 163 pinched by these plates and the opposite transparent electrodes 164 and 165 of the pair which is prepared in the monotonous inside which counters, respectively and impresses an electrical potential difference to a liquid crystal layer, diffraction-grating 16e (DOE: diffractive optical element) prepared on the inside which faced the monotonous liquid crystal layer of one of these — since — it becomes. The transparent electrode layers 164 and 165 which are inside the plates 161 and 162 of diffracted-light study component 16b are formed of ITO etc. The electrode 165 is divided on the inside and the outside. The transparent electrode for this liquid crystal control is halved in and abroad by the electrode parting line, and it is used in order to restrict NA at the time of CD playback. The radius of a parting line is decided by NA (about [Usually] 0.45) required for CD playback, and is the ratio of NA0.6 of DVD playback, and it is desirable to divide about [of an objective lens effective diameter] by 3/4.
[0027] Diffraction-grating 16e in contact with liquid crystal has the Fresnel lens or hologram lens which consists of the zona orbicularis, i.e., two or more irregularity, of the circular sulcus by which was formed by the pattern which has the symmetry-of-revolution medial axis arranged at the core of an optical path, and was cut by two or more concentric circles centering on the optical axis, or the laminating was carried out with phot lithography, or a convex, as shown in drawing 2 . As are shown in drawing 3 , and the cross section shows a blaze configuration, i.e., serrate, or drawing 4 , diffraction-grating 16e is formed so that it may become a stairway configuration. For example, since diffraction efficiency is higher than others, the diffraction grating of a serrate cross section is advantageous.
[0028] Diffraction-grating 16e is formed in the radius field equivalent to the numerical aperture of condenser lens 16a required in order to realize the diameter of condensing SUBOTTO required for playback of HD-DVD or DVD by the shape of a hologram pattern of a concentric circle. Moreover, the hologram pattern of diffraction-grating 16e is the same as the interference pattern at the time of making the light which carried out outgoing radiation from the semiconductor laser of blue or red, and carried out incidence to diffracted-light study component 16b after penetrating optics, such as a collimate lens 14, and the light which penetrated condenser lens 16a after being reflected by the recording layer of HD-DVD or DVD, and carried out incidence to diffracted-light study component 16b interfere on the field which forms a diffraction grating. That is, when the primary diffracted light arises, the hologram pattern of a diffraction grating is set up so that it may have aberration which negates the spherical aberration generated when light penetrates the disk substrate of an objective lens 5, HD-DVD, or DVD.
[0029] Diffraction-grating 16e is designed so that a concave lens operation may be made to blue or red. furthermore, diffraction-grating 16e — condenser lens 16a — minding — blue and red — the primary more than diffracted light — as information reading light or information record light — condensing — infrared rays — zero — it is designed so that the following diffracted light may be made to condense as information reading light or an information record light.

[0030] There is the approach of carrying out precision cutting with the approach of applying a photolithography technique, a diamond tool, etc., as a method of creating diffraction-grating 16e of a serration or a stairway cross-section configuration. By these, the diffraction grating of the multistage story blaze which formed the blaze in false, or a blaze configuration can form on a transparent electrode. The form is formed in metal mold for the multistage story blaze or the blaze configuration, and a diffraction grating can also be reproduced from transparence plastic material by injection molding or 2P so-called law. A rectangle is sufficient as the cross-section configuration of diffraction-grating 16e, and the structure in which a refractive index carries out periodic change is sufficient as the cross section flat tabular.
[0031] Thus, the pitch P of the diffracted-light study component which has diffraction-grating 16e of a concentric circular pattern is defined with a design value. The wavelength dependency of aberration improves so that the pitch of a diffraction grating becomes fine, but if a pitch becomes 5 or less times of wavelength, diffraction efficiency will fall greatly theoretically. Moreover, the effect by configuration gap becomes large, so that a pitch is fine. So, with the gestalt of this operation, a configuration gap of pitch 1micrometer makes 20 micrometers or more a desirable value as a value which corresponds to 5%. Moreover, the pitch of a diffracted-light study component is designed so that blue, the conditions by which chromatic aberration is amended to red wavelength, the conditions by which aberration is amended to the infrared wavelength at the time of CD playback, and the conditions which amend the difference by 1.2m from 0.6mm of disk substrate thickness may be fulfilled as a result combined with the configuration of a concave lens. In order to change NA at the time of CD playback, the above-mentioned inside and a ground electrode perform by adjustment of the seal-of-approval electrical potential difference in an inside-and-outside periphery.
[0032] The depth of the blaze of a diffraction grating is decided as follows. The refractive index of liquid crystal is set to nlc, and the refractive index of the base material which forms the blaze is set to n. Depth L from which the Mth diffracted light becomes max (M is an integer) when wavelength of the light source to be used is set to lambda becomes the greatest value when filling a degree type.
[0033]
[Equation 1] L=M-lambda/(nlc-n)
Therefore, it is necessary to define L, M, n, and nlc so that the above-mentioned formula may be filled with each wavelength. The refractive index nlc of liquid crystal changes with the seal-of-approval electrical potential differences to give, and can take the value between the maximum n|| (parallel to the direction of a major axis of a liquid crystal molecule), and minimum value n** (perpendicular to a liquid crystal major axis) here. An actual numeric value is put in and calculated based on the above thing.
[0034] blue and red -- the primary diffracted light and infrared rays -- as the zero-order diffracted light and a blaze base material -- about [refractive-index], if ZLI-5049 (nlc=1.5-1.7) of Merck Co. is used as a liquid crystal ingredient using photopolymer ******** 2P of n= 1.5 Since it is lambda= 0.4 micrometers, M= 1, n= 1.5, and nlc=1.7 in HD-DVD, it is set to L= 2 micrometers, and in the case of DVD, since it is lambda= 0.65 micrometers, M= 1, n= 1.5, and nlc=1.7, it is set to L= 3.25 micrometers. In the case of CD, it is set to lambda= 0.78 micrometers, M= 0, n= 1.5, and nlc=1.5.
[0035] From this, that what is necessary is just to set it as L= 3.25 micrometers of thickest DVD, blaze depth L will satisfy the above-mentioned formula, if the value of nlc is set to 1.623 to the wavelength of 0.4 micrometers of HD-DVD. In the configuration of diffracted-light study component 16b of drawing 2 , naturally the thickness of a liquid crystal layer needs to be thicker than Above L, and is set as about 5-20-micrometer thickness. As for the thickness of the substrate of a glass plate, 0.7mm - 1.1mm is usually used.
[0036] central transparent electrode 165a by which the counterelectrode 165 with which it is divided under diffraction-grating 16e has been arranged at the symmetry-of-revolution medial axis of a diffraction grating as shown in drawing 2 , and annular transparent electrode 165b arranged the surroundings -- since -- it becomes. transparent electrodes 164 and 165 -- each thickness is set as thickness which light does not diffract for transparent electrode itself. A center and the annular transparent electrodes 165a and 165b are connected to the armature-voltage control circuit 168, i.e., the armature-voltage control means, of impressing an electrical potential difference independently to these. The suitable electrical potential difference for liquid crystal is given so that respectively high diffraction efficiency may be acquired in the optical-path-length difference of a diffracted-light study component to the order of diffraction which needs infrared wavelength with blue and red. The required order of diffraction is the zero-order diffracted light to infrared rays to blue and red except the zero-order diffracted light.
[0037] As shown in drawing 2 , diffracted-light study component 16b has the plano-concave lens 170 which carried out the optical path in common. Although the plano-concave lens 170 has been arranged on the optical lower stream of a river of diffracted-light study component 16b and the crevice is turned to the condenser lens 16a side in drawing 2 , as shown in drawing 19 , diffraction-grating 16e is prepared on the translucency plate 161 of the optical upstream at electrode 165a and the 165b list which control the liquid crystal of a component, and turning a crevice to a light source side and being arranged in the optical upstream of diffracted-light study component 16b, also has a desirable plano-concave lens 170. A concave lens 170 is usually a single lens, and a concave surface is formed in the spherical surface or the aspheric surface. Although field of one of the two may already be the spherical surface, plane one of a manufacture top is simple. Although a concave lens 170 is usually arranged apart from a liquid crystal diffracted-light study component, as shown in drawing 2 , it can be pasted up with the monotonous substrate of liquid crystal. Moreover, in order to reduce the number of components, it can also constitute so that a concave lens 171 may make the glass substrate of liquid crystal serve a double purpose, as shown in drawing 5 . Although the unified concave lens 171 was located in the optical downstream of diffracted-light study component 16b and the crevice is turned to the condenser lens 16a side in drawing 5 , as shown in drawing 20 R> 0, like the configuration of drawing 19 , it is located in the optical upstream of diffracted-light study component 16b, and a crevice can be turned to a light source side and it can also unite with the translucency substrate of a component. It is because the effect to which a wavelength dependence property improves with a concave lens, and is deteriorating with a convex lens on the contrary arises to the property of condenser lens 16a which fixed the best image point to use the substrate of diffracted-light study component 16b as a concave lens.
[0038] Furthermore, it is also possible to arrange a collimator lens 14 on the light source side front face of the plate 161 of the translucency of liquid crystal diffracted-light study component 16b, as shown in drawing 6 . If it is made such a design, the condenser lens 16a side concave lens can be excluded. In three waves of each condition, it is determined that the above-mentioned lens system and the design of a diffracted-light study component satisfy engine performance including a condenser lens. The reason is that power of composition of a condenser lens and a diffracted-light study component can be set to about 0 on one of wavelength, and it can make tolerance, such as location precision, loose. Furthermore, the order of diffraction of the diffracted-light study component to be used is set up according to it. For example, red and blue have combination possible for the primary diffracted light and infrared rays, such as combination of the zero-order diffracted light or the secondary blue

diffracted light, the primary red diffracted light, and the infrared zero-order diffracted light, at the time of the condenser lens of usual optical glass. Moreover, when using the above-mentioned 2P objective lens, red and blue are possible for the combination of the zero-order diffracted light and the infrared zero-order diffracted light. Furthermore, the diffracted light of the minus order of diffraction other than the diffracted light of the plus order of diffraction can also be used.

[0039] Since diffracted-light study component 16b is the structure whose liquid crystal layer 163 was pinched between annular transparent electrode 165b and the transparent electrodes 164 which were formed in central transparent electrode 165a and its outside, if an electrical potential difference is impressed independently of in between [electrode 165b, a transparent electrode 164, and in between] electrode 165a, a transparent electrode 164, and in between, diffracted-light study component 16b will achieve the following two functions according to an electrical-potential-difference impression gestalt.

[0040] As shown in drawing 7 , diffracted-light study component 16b has the function which makes equal the polarization direction of light where the liquid crystal layer 163 penetrates the outside and the inside of central transparent electrode 165a by impressing the same electrical potential difference to two electrodes 165a and 165b. Furthermore, as shown in drawing 8 , diffracted-light study component 16b has the function to rotate the 90 degrees of the polarization directions of light where the liquid crystal layer 163 penetrates the outside of central transparent electrode 165a to the polarization direction of the light which penetrates central transparent electrode 165a, by impressing an electrical potential difference which is different in two electrodes 165a and 165b. Therefore, the effectual numerical aperture of condenser lens 16a can be changed to two electrodes 165a and 165b by carrying out electrical-potential-difference impression. The armature-voltage control circuit 168 impresses the same electrical potential difference to central transparent electrode 165a and annular transparent electrode 165b at the time of an exposure of blue or red, and makes the control which impresses an electrical potential difference which is different in two electrodes 165a and 165b at the time of an infrared exposure. Thereby, diffracted-light study component 16b has the high effectiveness of the infrared zero-order diffracted light, on a periphery, is made low and demonstrates the effectiveness of restricting NA at inner circumference.

[0041] Next, actuation of diffracted-light study component 16b is explained. As shown in drawing 1 , when equipment is loaded with an optical disk, by means (not shown) to identify the class of optical disk, the class of optical disk is identified, consequently a recognition signal is supplied to a controller 30. According to a loading optical disk, a controller 30 drives the armature-voltage control circuit 168, and the seal of approval of the liquid crystal operating voltage set up beforehand is carried out to the liquid crystal layer 163 through central transparent electrode 165a and annular transparent electrode 165b.

[0042] In addition, what is necessary is just to carry out servo actuation so that the light-receiving quantity of light of the light-receiving side 20 of a detector may always become max when having shifted from the optimal seal-of-approval electrical potential difference with the setting error and ambient temperature of a liquid crystal seal-of-approval electrical potential difference. At the time of CD or CD-R playback, to the predetermined order of diffraction, inner circumference sets up the seal-of-approval electrical potential difference given to central transparent electrode 165a and annular transparent electrode 165b of an inside-and-outside periphery so that the maximum effectiveness and a periphery may become the minimum effectiveness. This is also realizable by thing which always make the optimal the RF signal and jitter from the light-receiving side 20 of a detector and which is done for servo actuation.

[0043] As an optical pickup which has such a function, the optical pickup in which a diffraction grating contains the objective lens unit which designed the diffracted-light study component using the zero-order diffracted light as a symmetry-of-revolution object to the primary diffracted light and infrared rays (780nm) to the primary diffracted light and red (650nm) to blue (405nm) was produced. It is 0.6mm of disk substrate thickness in NA=0.61, and the conditions of an optical disk are 0.6mm of disk substrate thickness in NA=0.60, and are [in 405nm of blue / in 650nm of red] 1.2mm of disk substrate thickness in NA=0.45 at infrared 780nm.

[0044] The diffracted-light study component of the lens of **** has been arranged at the light source side of the condenser lens of the aspheric surface, the diffraction grating was formed on the concave surface, and each of concave surfaces and diffraction gratings was made into the aspheric surface configuration. Therefore, the 1st page and the 2nd page are the plane of incidence and the outgoing radiation sides of a diffracted-light study component, and the 3rd page and the 4th page are the plane of incidence and the outgoing radiation sides of a condenser lens. Each aspheric surface Z is expressed with the-two number of degree types.

[0045]

[Equation 2]

$$Z = \frac{(1/R)r^2}{1+\sqrt{1-(1/R)^2(K+1)r^2}} + \sum_i ASir^i$$

[0046] (However, the amount of Z:SAG, R:radius of curvature, K:constant of the cone, the radius from r:optical axis, ASi: Aspheric surface multiplier)

Phase function phi (r) is expressed with the-three number of **** types.

[0047]

[Equation 3]

$$\Phi(r) = dor\frac{2\pi}{\lambda_0}(DF0 + DF1r^2 + DF2r^4 + DF3r^6 + DF4r^8 + DF5r^{10})$$

[0048] (However, the dor:order of diffraction, lambda0:wavelength, the radius from r:optical axis, DF1-DF5: Multiplier)

The data of each aspheric lens by which design automation was carried out are as in Tables 1-3.

[0049]

[Table 1]

	面番号	曲率半径	面間隔	屈折率
回折光学素子	1	-44.000000	1.000000	1.605256
	2	—	0.300000	
集光レンズ	3	2.161300	1.798000	1.605256
	4	-17.079390	1.000000	
ディスク	5	—	0.600000	1.621082
	6	—	0.878702 V	

[0050]
[Table 2]

		第1面	第3面	第4面
非球面係数	AS2	0.000901	-0.000738	0.008569
	AS3	-0.000189	-0.000211	-0.003385
	AS4	7.7143e-05	-0.000123	0.000760
	AS5	-2.3508e-06	2.9546e-06	-6.4927e-05
円錐係数	(K)	325.035360	-0.418560	17.362981

[0051]
[Table 3]

	第1面
DF0	-0.000200
DF1	-0.003646
DF2	0.000172
DF3	-0.000103
DF4	3.2853e-05
DF5	-2.2250e-06

[0052] The change C of the wave aberration to the change B and CD (optical disk thickness of 1.2mm, light source wavelength of lambda= 780**10nm) of the wave aberration to the change A and DVD (optical disk thickness of 0.6mm, light source wavelength of lambda= 650**10nm) of the wave aberration to HD-DVD (optical disk thickness of 0.6mm, light source wavelength of lambda= 405**5nm) of the objective lens unit obtained by drawing 9 is shown. The wavelength dependency which took wavelength along the axis of abscissa and took the amount of wave aberration on an optical axis (rms (lambda)) along the axis of ordinate in drawing 9 is shown. The wave aberration of an objective lens unit is stopped also in which wavelength below at MARESHARU marginal 0.07lambda so that it may illustrate.
[0053] thus, the diffraction grating of this invention — a condenser lens — minding — blue and red — an absolute value — the primary more than diffracted light — as information reading light or information record light — condensing — infrared rays — zero, although it is designed so that the following diffracted light may be made to condense as information reading light or an information record light Furthermore, a diffraction grating may be designed so that the 1st light beam diffracted light of the order of diffraction high about blue may be condensed as information reading light or an information record light and the 2nd light beam diffracted light of the order of diffraction of a low degree may be condensed as information reading light or an information record light from the high order of diffraction about red.
[0054] For example, diffraction-grating 16e of diffracted-light study component 16b As shown in drawing 10 , when the 1st blue light beam with a wavelength of 405nm penetrates, While being formed so that it may condense on an HD-DVD disk recording surface through condenser lens 16a as information reading light or an information record light, the secondary diffracted-light B-2 As diffraction-grating 16e is shown in drawing 1111 at coincidence, when the 2nd light beam of red with a wavelength of 650nm penetrates, It is formed so that the primary diffracted light R1 of a low degree may be condensed on a DVD disk recording surface through an objective lens as information reading light or an information record light from the secondary diffracted light of the 1st light beam diffracted light. Since zero-order [blue] and the primary diffracted lights B0 and B1 will be in a focus condition in the red zero-order diffracted light R0 and a red high order diffracted-light list on a disk recording surface in these cases, these diffracted lights hardly influence reading or record. Although the 1st and 2nd light beams of the light source, i.e., the wavelength range of the semiconductor laser of red and blue, are made into red (630-660nm) and blue (400-410nm) in the above-mentioned example, respectively, it is because diffraction efficiency will not change a lot if it is this range. Furthermore, as for the 1st order of diffraction of the 1st light beam diffracted light, only 1 is larger than the 2nd order of diffraction of the 2nd light beam diffracted light, and, as for the 2nd order of diffraction of the 2nd light beam diffracted light, it is desirable that it is one or more. Therefore, when the 3rd diffracted light with a wavelength of 405nm other than the above-mentioned example whose 2nd light beam diffracted light is the primary diffracted light when the 1st light beam diffracted light is the secondary diffracted light is used for HD-DVD at the 1st light beam diffracted light, diffraction-grating 16e of diffracted-light study

component 16b may be produced so that the secondary diffracted light may be condensed as the 2nd light beam diffracted light with a wavelength of 650nm for DVD.
[0055] Using the diffraction grating which does not have to infrared rays, zero-order diffracted light, i.e., power, without using the zero-order blue diffracted light with red, using the secondary blue diffracted light, in this operation gestalt, the diffraction grating is formed in red so that the primary diffracted light of a low degree [one] may be used from the 2nd order. That is, the diffraction grating of this invention is formed so that the respectively high rate of the diffracted light may be obtained in the optical-path-length difference to the order of diffraction which needs blue wavelength with red.
[0056] For example, change of the diffraction efficiency of a diffraction grating at the time of producing the diffracted-light study component which consists of plastic material of OZ-1000 (Hitachi Chemical) as a base material is computed by changing depth d of a diffraction grating to 0-3 micrometers, using a pitch P as 160-260 micrometers for the diffraction grating of a blaze cross-section configuration. Since the pitch is longer than wavelength enough, the diffraction grating in the gestalt of operation can apply the scalar theory, and since the depth is wavelength extent, it can treat it as the so-called thin film grating. In that case, diffraction-efficiency etam is expressed with the-one number of degree types (m is the order of diffraction).
[0057]
[Equation 4]

$$\eta m = \left|\frac{1}{T}\int_0^T A(x)\exp\{i\varphi(x)\}\exp(-i\frac{2\pi mx}{T})dx\right|^2$$

[0058] Among the formula, in A (x), transparency amplitude distribution and psi (x) show phase distribution, and T shows the pitch of a grating. In count, it has standardized as A(x) =1. Moreover, the wavelength dependency of aberration improves so that a pitch generally becomes fine about the pitch of a diffraction grating, but if a pitch becomes 5 or less times of wavelength, diffraction efficiency will fall greatly theoretically. Moreover, the effect by configuration gap becomes large, so that a pitch is fine. So, with the gestalt of this operation, a configuration gap of pitch 1micrometer makes 20 micrometers or more a desirable value as a value which corresponds to 5%.
[0059] Drawing 12 is the result of computing depth [of a diffraction grating] d on an axis of abscissa, and computing change of the diffraction efficiency of a diffraction grating on an axis of ordinate. "B0" in drawing, "B1", "B-2", and "B3" show the diffraction efficiency of the blue zero-order diffracted light, the primary diffracted light, the secondary diffracted light, and the 3rd diffracted light, and "R0", "R1", and "R2" show the diffraction efficiency of the red zero-order diffracted light, the primary diffracted light, and the secondary diffracted light, respectively.
[0060] As for the blaze-ized diffraction grating, diffraction efficiency takes [the phase depth] maximum with the period of every one wave lambda of light so that clearly from drawing 12 . The phase depth of a diffraction grating is expressed with these products d (n-1), when d is made into the depth of an actual diffraction grating and it makes n the refractive index of a diffracted-light study component base material. Since it is rate nR=of isometropia 1.498, if it calculates to the wavelength of lambda= 650nm by refractive-index nB=1.531 of a base material ingredient after this to the wavelength of lambda= 405nm, the depth of the diffraction grating from which phase contrast is set to one wave lambda by 405nm will be 0.763 micrometers, and the diffraction efficiency of the blue primary diffracted light will become max in this depth. the blue secondary diffracted light — the twice — 1.526 micrometers of red primary diffracted lights serve as max by 1.305 micrometers similarly.
[0061] It turns out that the depth of the diffraction grating from which the high rate of the diffracted light is obtained from these things on any blue wavelength with red is the intersection of R1 and B-2, and the intersection of R2 and B3. That is, near 1.42 micrometer used by secondary diffracted-light B-2 of the blue of the 1st wave and the primary diffracted light R1 of the red of the 2nd wave and near 2.4 micrometer which are used by the 3rd blue diffracted light B3 and the red secondary diffracted light R2 are the depth of the diffraction grating from which the rate of the high diffracted light is obtained. Since it will become about about ten% of effectiveness reduction if 0.2 micrometers of depth of a diffraction grating shift, in order to secure more than this, it is desirable that the depth of the diffraction grating from which the rate of the high diffracted light is obtained considers as within the limits of 1.42**0.2 micrometers or 2.40**0.2 micrometers.
[0062] Moreover, although the rate of the diffracted light is by no means as low as about 80% also on the intersection (the depth of a diffraction grating is 0.965 micrometers) of the primary diffracted light B1 of the blue of the 1st light, and the primary diffracted light R1 of the red of the 2nd wave, if a gap arises in the depth of a diffraction grating, diffraction efficiency will fall greatly, so that clearly from drawing 12 . Although there is little fluctuation of diffraction efficiency if it is an intersection blue and near the peak of red diffraction efficiency even if a gap arises in the depth of a diffraction grating since the peaks of the diffraction efficiency of the blue secondary diffracted light [3rd] are a depth of 1.526 micrometers, and 2.289 micrometers and it is 1.305 micrometers and 2.610 micrometers in red primary secondary diffracted light similarly, on the intersection which separates from each peak, it changes sharply.
[0063] According to this invention, when using the lens which could realize the optical pickup which each information playback of CD further using the infrared laser light source and CD-R is possible, and carries out compatibility to HD-DVD using the blue laser light source, and DVD using the red laser light source possible with one objective lens corresponding to a total of three waves, and was amended in blue or the red wavelength range as an objective lens, the design eased far is attained.
(Gestalt of the 2nd operation) As shown in drawing 13 , it replaces with diffracted-light study component 16b using the liquid crystal equipment of the above-mentioned operation gestalt, and the armature-voltage control circuit 168, and the same optical pickup as the above-mentioned operation gestalt may be constituted except having formed the polarization diffracted-light study component 169 using a polarizing element. Moreover, this diffracted-light study component 16 is good also as a configuration which has the plano-concave lens which turned the crevice to the condenser lens side. Furthermore, a diffracted-light study component can also have the plano-concave lens which was united with the complementary translucency parallel plate by the side of a condenser lens, and turned the crevice to the condenser lens side.
[0064] As shown in drawing 14 , this polarization diffracted-light study component 169 consists of anisotropy optical material substrate 169a which formed the crevice of diffraction-grating 16e designed by the above-mentioned technique in the monotonous principal plane which consists of an anisotropy optical material of the uniaxial crystal of lithium niobate etc., and restoration section 169b with which the crevice which consists of isotropic ingredients, such as optical glass, was filled up, and makes both principal planes an parallel flat surface. Anisotropy optical material substrate 169a is located in a light source side. namely, diffraction-grating 16e formed on translucency parallel plate 169a which a diffracted-light study component becomes from an anisotropy optical material and complementary translucency parallel plate 169b which consists of an isotropic optical material with which the diffraction grating was filled up — since — it becomes. Diffraction-grating 16e is formed so that it may

act as a concave lens and the cross section may serve as a blaze configuration preferably. In the optical-path-length difference of a diffracted-light study component, respectively high diffraction efficiency is acquired to two waves of required degrees, blue and red. That is, the level difference depth of a diffraction grating is set as a value with high effectiveness to blue wavelength with red.

[0065] If the optical axis of anisotropy optical material substrate 169a is arranged in the direction which met the flat surface, for example as shown in drawing 14 , as shown in drawing 15 and drawing 16 , abnormality light and Tsunemitsu will produce the light which carried out incidence perpendicularly. Then, complementary translucency parallel plate 169b is formed with the isotropic optical material which has a refractive index equal to the refractive index in Tsunemitsu of anisotropy optical material substrate 169a. In this case, the polarization direction where it and the polarization direction of the light of red and blue which carries out incidence to a polarization diffracted-light study component cross at right angles to nothing and the polarization direction of infrared light identically to the polarization direction where anisotropy optical material substrate 169a acts is used. That is, if infrared, main plane of polarization is made to incline 90 degrees as opposed to the main plane of polarization of other light among blue, red, and an infrared light beam, as are shown in drawing 15 , and it acts as a diffracted-light study component to the 1st bearing (space parallel) of blue and red and is shown in drawing 16 , the 2nd infrared bearing (space perpendicular) which intersects perpendicularly with it will become isotropic, and will become a mere glass parallel plate and equivalence. In addition, if the direction of incidence of a light beam and the optical axis of anisotropy optical material substrate 169a are not made parallel, since abnormality light and Tsunemitsu arise, the optical axis of the uniaxial crystal of an anisotropy optical material should just incline to the direction of incidence of a light beam.

[0066] Thus, the conditions using [red / the primary diffracted light and blue the secondary diffracted light, and] the diffracted light of the zero-order diffracted light in infrared rays come to be fulfilled by carrying out incidence of the laser of red and blue in the 1st bearing, and making it put ON in the 2nd bearing about infrared rays. As shown in drawing 17 , the z-axis is made into the direction of incidence with a rectangular xyz coordinate. A x axis The plane of polarization of abnormality light, When the y-axis is set up with Tsunemitsu's plane of polarization, as a means to make the plane of polarization of the light beam of blue and red incline to the plane of polarization of an infrared light beam As blue, red semiconductor laser LD1 for HD-DVD, and semiconductor laser LD2 for DVD are arranged so that the plane of composition in those laser structures may become parallel to a x axis, and they are shown in drawing 18 What is necessary is just to arrange infrared CD and semiconductor laser LD3 for CD-R so that the plane of composition may become parallel to a perpendicular, i.e., the y-axis, in a x axis. Moreover, even if it inserts a wavelength plate in infrared CD and the optical path of only semiconductor laser LD3 for CD-R, the plane of polarization of a laser beam can be inclined.

[0067] moreover -- although armature-voltage control like the above-mentioned liquid crystal diffracted-light study component is unnecessary, since an opening limit cannot be performed -- the time of the light beam exposure of infrared rays offering [and] effective opening at the time of a light beam exposure of blue or red -- effective opening -- smallness -- it has the opening control means which offers effective opening. If the 2nd dichroic mirror 200 is arranged to the optical path of only semiconductor laser LD3 for CD-R as shown in drawing 18 as an opening control means, it can realize comparatively easily.

[0068] Thereby, the structure of the compatible player for DVD and HD-DVD can be simplified extremely, and miniaturization low cost-ization of pickup is attained.

[0069]

[Effect of the Invention] According to this invention, the diffracted-light study component in an optical pickup And it sets to the optical pickup equipped with the diffracted-light study component containing a diffraction grating. red, blue, and the infrared light source -- a preparation -- About the 1st and 2nd light beams, the primary more than diffracted light is condensed as information reading light or an information record light through a condenser lens. the 3rd light beam -- zero -- the optical disk or recording surface from which correspondence wavelength differs since the diffraction grating which the cross section which makes the following diffracted light condense as information reading light or an information record light becomes from the irregularity of serrate or a stairway configuration is used -- receiving -- record -- a refreshable miniaturization optical pickup can be obtained.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is an outline block diagram inside the optical pickup of the operation gestalt by this invention.
[Drawing 2] It is the partial notching perspective view of the diffracted-light study component in the optical pickup by this invention.
[Drawing 3] It is the fragmentary sectional view of the diffraction grating in the optical pickup by this invention.
[Drawing 4] It is the fragmentary sectional view of the diffraction grating in the optical pickup by this invention.
[Drawing 5] It is the partial notching perspective view of the diffracted-light study component in the optical pickup of other operation gestalten by this invention.
[Drawing 6] It is the partial notching perspective view of the diffracted-light study component in the optical pickup of other operation gestalten by this invention.
[Drawing 7] It is the fragmentary sectional view of the objective lens unit in the optical pickup by this invention.
[Drawing 8] It is the fragmentary sectional view of the objective lens unit in the optical pickup by this invention.
[Drawing 9] It is the graph which shows change of the wave aberration to the infrared zero-order diffracted light to the blue of an objective lens unit, and a red primary diffracted-light list.
[Drawing 10] It is the fragmentary sectional view of the objective lens unit in the optical pickup by this invention.
[Drawing 11] It is the fragmentary sectional view of the objective lens unit in the optical pickup by this invention.
[Drawing 12] It is the graph which shows the relation of the depth of the diffraction grating of an objective lens unit and diffraction efficiency in an optical pickup by this invention.
[Drawing 13] It is an outline block diagram inside the optical pickup of other operation gestalten by this invention.
[Drawing 14] It is the partial notching perspective view of the diffracted-light study component in the optical pickup of other operation gestalten by this invention.
[Drawing 15] It is the fragmentary sectional view of the diffracted-light study component in the optical pickup of other operation gestalten by this invention.
[Drawing 16] It is the fragmentary sectional view of the diffracted-light study component in the optical pickup of other operation gestalten by this invention.
[Drawing 17] It is the outline partial perspective view of the important section in the optical pickup of other operation gestalten by this invention.
[Drawing 18] It is the outline partial perspective view of the important section in the optical pickup of other operation gestalten by this invention.
[Drawing 19] It is the outline partial notching perspective view of the diffracted-light study component in the optical pickup of other operation gestalten by this invention.
[Drawing 20] It is the outline partial notching perspective view of the diffracted-light study component in the optical pickup of other operation gestalten by this invention.
[Description of Notations]
1 Optical Pickup
5 Optical Disk
10 Optical-Axis Joint Prism
11 Dichroic Mirror Composition Side
13 Polarization Beam Splitter
14 Collimator Lens
15 Quarter-wave Length Plate
16 Objective Lens Unit
16a Condenser lens
16b Diffracted-light study component
16c Holder
16e Diffraction grating
20 Photodetection Section Light-receiving Side
26 Actuator
30 Controller
31 Error Detection Circuit
33 Drive Circuit
LD1 The 1st semiconductor laser
LD2 The 2nd semiconductor laser
LD3 The 3rd semiconductor laser

[Translation done.]

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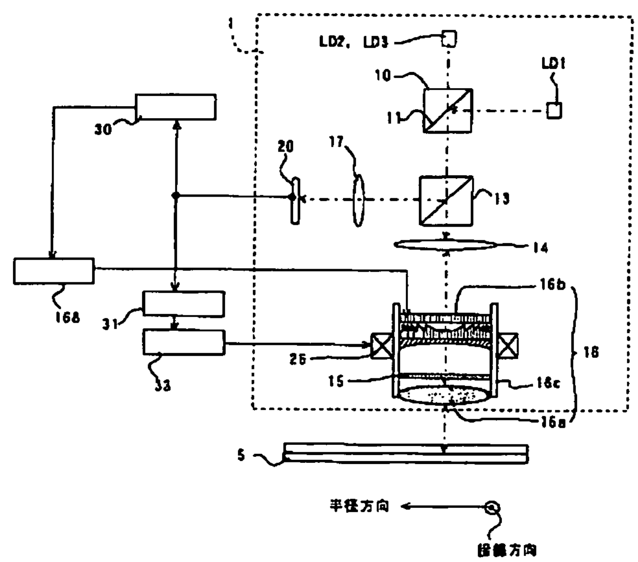
(54)【発明の名称】　光ピックアップ

(57)【要約】

【課題】　対応波長の異なる光ディスク又は記録面に対し記録再生可能な小型化に適した光ピックアップを提供する。

【解決手段】　第１波長を有する第１光ビームを出射する半導体レーザの第１の光源と、第１波長より長い第２波長を有する第２光ビームを出射する半導体レーザの第２の光源と、第２波長より長い第３波長を有する第３光ビームを出射する半導体レーザの第３の光源と、第１、第２及び第３光ビームの光路を共通化させる光軸結合素子と、第１、第２及び第３光ビームを記録媒体の情報記録面に集光させる集光レンズと、を備えた光ピックアップであって、第１、第２及び第３の光源から集光レンズまでの光路中に配置されかつ光路の中心に配置された回転対称中心軸を有する回折格子を含む回折光学素子を備え、回折格子は、集光レンズを介して、第１及び第２光ビームについては絶対値が１次以上の回折光を情報読取光又は情報記録光として集光し、第３光ビームについてはゼロ次の回折光を情報読取光又は情報記録光として集光せしめる断面形状を有する。



【特許請求の範囲】

【請求項1】 第1波長を有する第1光ビームを出射する半導体レーザの第1の光源と、第1波長より長い第2波長を有する第2光ビームを出射する半導体レーザの第2の光源と、第2波長より長い第3波長を有する第3光ビームを出射する半導体レーザの第3の光源と、前記第1、第2及び第3光ビームの光路を共通化させる光軸結合素子と、前記第1、第2及び第3光ビームを記録媒体の情報記録面に集光させる集光レンズと、を備えた光ピックアップであって、

前記第1、第2及び第3の光源から前記集光レンズまでの光路中に配置されかつ前記光路の中心に配置された回転対称中心軸を有する回折格子を含む回折光学素子を備え、

前記回折格子は、前記集光レンズを介して、前記第1及び第2光ビームについては絶対値が1次以上の回折光を情報読取光又は情報記録光として集光し、前記第3光ビームについてはゼロ次の回折光を情報読取光又は情報記録光として集光せしめる断面形状を有することを特徴とする光ピックアップ。

【請求項2】 前記回折光学素子は、一対の平行に対向した透光性の平板と、前記平板に挟まれた液晶層と、前記平板の対向する内面にそれぞれ設けられ前記液晶層に電圧を印加する一対の対向電極と、前記平板の一方の前記液晶層に面した前記対向電極上に設けられた前記回折格子と、からなり、

前記一対の対向電極の少なくとも一方は、前記回転対称中心軸に配置された中央透明電極と、前記中央透明電極の周り配置された環状透明電極と、からなり、

前記第1又は第2光ビーム照射時には前記中央透明電極及び前記環状透明電極に同一電圧を印加し、前記第3光ビーム照射時には前記中央透明電極及び前記環状透明電極に異なる電圧を印加する電圧制御手段を備えたことを特徴とする請求項1記載の光ピックアップ。

【請求項3】 前記回折光学素子は前記光路を共通とする平凹レンズを有していることを特徴とする請求項2記載の光ピックアップ。

【請求項4】 前記回折光学素子は前記平板と一体化された平凹レンズを有し、前記回折格子は前記平凹レンズの平面に形成されていることを特徴とする請求項2記載の光ピックアップ。

【請求項5】 前記回折光学素子は、異方性光学材料からなる透光性平行平板上に形成された前記回折格子と、前記回折格子に充填された等方性光学材料からなる相補的透光性平行平板と、からなり、

前記第1、第2及び第3光ビームのうちの1つの光の主要な偏光面を他の光の主要な偏光面に対して傾斜させる手段を有し、

前記第1又は第2光ビーム照射時には有効開口を提供しかつ、前記第3光ビーム照射時には前記有効開口より小なる有効開口を提供する開口制御手段を備えたことを特徴とする請求項1記載の光ピックアップ。

【請求項6】 前記回折光学素子は前記集光レンズ側に凹部を向けた平凹レンズを有していることを特徴とする請求項5記載の光ピックアップ。

【請求項7】 前記回折光学素子は前記集光レンズ側の前記相補的透光性平行平板と一体化され前記集光レンズ側に凹部を向けた平凹レンズを有することを特徴とする請求項5記載の光ピックアップ。

【請求項8】 前記開口制御手段はダイクロイックミラーであることを特徴とする請求項5～7のいずれか1記載の光ピックアップ。

【請求項9】 前記第1、第2及び第3光ビームのうちの1つの光の主要な偏光面を他の光の主要な偏光面に対して傾斜させる角度は90度であることを特徴とする請求項5～8のいずれか1記載の光ピックアップ。

【請求項10】 前記異方性光学材料は一軸結晶であり、その光学軸が前記第1、第2及び第3光ビームの入射方向に対し傾斜していることを特徴とする請求項5～9のいずれか1記載の光ピックアップ。

【請求項11】 前記回折光学素子は前記第1又は第2光ビームに対し凹レンズ作用をなすことを特徴とする請求項1～10のいずれか1記載の光ピックアップ。

【請求項12】 前記集光レンズは、第1及び第2光ビームの波長範囲で収差が補正されたレンズであることを特徴とする請求項1～11のいずれか1記載の光ピックアップ。

【請求項13】 前記回折格子は、前記集光レンズを介して、前記第1光ビームについては第1回折次数の第1光ビーム回折光を情報読取光又は情報記録光として集光し、前記第2光ビームについては前記第1回折次数より低次の第2回折次数の第2光ビーム回折光を情報読取光又は情報記録光として集光することを特徴とする請求項1～12のいずれか1記載の光ピックアップ。

【請求項14】 前記第1光ビーム回折光が2次回折光であるとき前記第2光ビーム回折光は1次回折光であることを特徴とする請求項13記載の光ピックアップ。

【請求項15】 前記回折格子の断面が鋸歯状又は階段形状の凹凸からなることを特徴とする請求項1～14のいずれか1記載の光ピックアップ。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、対応波長の異なる光ディスクから情報を記録再生する光学式記録再生装置における光ピックアップの光学系に関し、特に、異なる波長のレーザ光源を使うCD、CD－R、DVD及びHD－DVDへの互換性を可能にする光ピックアップに関する。

【0002】

【従来の技術】光学式記録再生装置には、光記録媒体の

例えばCD(compact disc)、CD－R(compact disc rewritable)、DVD(digital video disc)等の光ディスクから記録情報を読み取りできる光学式ディスクプレーヤがある。近年のCD、CD－Rの普及はめざましいものがあるが、さらに大容量4．7GBのDVDが市場に導入されている。市場では更に高密度記録が可能なパッケージメディアの要求が強い。

【0003】記録密度の向上には、良く知られているように使用する光源の短波長化と対物レンズの開口数（NA）を高くすることが有効である。短波長化に関しては、GaN基板をベースにした短波長の半導体レーザ（例えば、波長405nm）の研究が進展をみせており実用化が近いレベルにある。短波長の半導体レーザを使った15GB程度の高密度DVD（HD－DVD）システムの研究も同様に進められている。

【0004】そこで、HD－DVD光学式記録再生装置には，CD、CD－R及びDVDから記録情報を読み取りできる互換性すなわちコンパチビリティが求められることになる。そのコンパチブル再生システムは、DVDを再生できることが当然のこととして義務づけられる。ここで問題になるのは、短波長のレーザではDVDディスクのうち2層ディスクを読めないことである。これは2層ディスクの中間層の短波長光ビームでの反射率が低いために生じる。従って、コンパチブルディスクプレーヤを実現するために、HD－DVDシステムは波長405nm付近の青色の光ビーム（以下、単に青ともいう）を発光するレーザに加えて波長650nm付近の赤色の光ビーム（以下、単に赤ともいう）を発光するレーザを搭載する必要がある。

【0005】さらに、CD－RをDVDの650nm付近及びHD－DVDの405nm付近で再生することはできない。色素層でできたCD－R記録層は、780nm近辺での反射率こそ高いがそれ以外の波長では急激に低下するからである。CDは記録面がアルミニウム反射層なので他の波長で再生可能だが、CD－Rを再生するには780nm近傍の光源を必要とする。因みに、CD、CD－Rでは基板厚は1．2mmであり、対応波長は780nm、対物レンズの開口数は0．45程度である。また、DVDでは基板厚は0．6mmであり、対応波長は635nm～655nm、対物レンズの開口数は0．6程度である。HD－DVDでは基板厚は0．6mmであり、対応波長は405nm、対物レンズの開口数は0．6程度である。

【0006】CD－Rを再生する要件は、780nm付近の波長で収差が補正されること、ディスク基板厚の違いを補正すること、NAを変えること、がある。従って、フルコンパチブルディスクプレーヤを実現するために、HD－DVDシステムは波長405nm付近の青色の光ビーム（以下、単に青ともいう）を発光するレーザに加えて波長650nm付近の赤色の光ビーム（以下、単に赤ともいう）を発光するレーザを搭載する必要がある。さらに、CD、CD－R用の波長780nm付近の赤外線の光ビーム（以下、単に赤外ともいう）を発光するレーザも搭載する必要がある。

【0007】しかし、対物レンズの持つ色収差のために、従来の単レンズで波長の異なる種々の光をほぼ無収差で集光することは難しい。このため、CD、CD－R、DVD及びHD－DVDのコンパチビリティを確保するためには何らかの工夫が必要となる。

【0008】

【発明が解決しようとする課題】そこで、CD、CD－R、DVD及びHD－DVDのコンパチブルプレーヤ用の光ピックアップの実現方法として、専用対物レンズを使う波長ごとに切替える方法が考えられるが、3種類の対物レンズを要すので複雑なレンズ切り替え機構が必要でコストが増大し、アクチュエータが大きくなるので小型化に不利である。また、他の方法として、対物レンズとコリメータレンズと組み合せる方法が考えられるが、対物レンズに対してコリメータが固定しているため、対物レンズの移動時の性能を維持することが難しい、などの問題が発生する。

【0009】いずれにしても、CD、CD－R、DVD及びHD－DVDのコンパチビリティーを確保するため複数光源を用い、専用のプリズム、レンズなどの光学系を構成すると、光ピックアップ又は光ヘッド全体が複雑になり、大型になる傾向がある。本発明は、上記課題に鑑みなされたものであり、対応波長の異なる光ディスク又は記録面に対し記録再生可能な小型化に適した光ピックアップを提供することにある。

【0010】

【発明を解決するための手段】本発明の光ピックアップは、第1波長を有する第1光ビームを出射する半導体レーザの第1の光源と、第1波長より長い第2波長を有する第2光ビームを出射する半導体レーザの第2の光源と、第2波長より長い第3波長を有する第3光ビームを出射する半導体レーザの第3の光源と、前記第1、第2及び第3光ビームの光路を共通化させる光軸結合素子と、前記第1、第2及び第3光ビームを記録媒体の情報記録面に集光させる集光レンズと、を備えた光ピックアップであって、前記第1、第2及び第3の光源から前記集光レンズまでの光路中に配置されかつ前記光路の中心に配置された回転対称中心軸を有する回折格子を含む回折光学素子を備え、前記回折格子は、前記集光レンズを介して、前記第1及び第2光ビームについては絶対値が1次以上の回折光を情報読取光又は情報記録光として集光し、前記第3光ビームについてはゼロ次の回折光を情報読取光又は情報記録光として集光せしめる断面形状を有することを特徴とする。

【0011】本発明の光ピックアップにおいては、前記回折光学素子は、一対の平行に対向した透光性の平板

と、前記平板に挟まれた液晶層と、前記平板の対向する内面にそれぞれ設けられ前記液晶層に電圧を印加する一対の対向電極と、前記平板の一方の前記液晶層に面した前記対向電極上に設けられた前記回折格子と、からなり、前記一対の対向電極の少なくとも一方は、前記回転対称中心軸に配置された中央透明電極と、前記中央透明電極の周り配置された環状透明電極と、からなり、前記第１又は第２光ビーム照射時には前記中央透明電極及び前記環状透明電極に同一電圧を印加し、前記第３光ビーム照射時には前記中央透明電極及び前記環状透明電極に異なる電圧を印加する電圧制御手段を備えたことを特徴とする。

【００１２】本発明の光ピックアップにおいては、前記回折光学素子は前記光路中を共通とする平凹レンズを有していることを特徴とする。本発明の光ピックアップにおいては、前記回折光学素子は前記平板と一体化された平凹レンズを有し、前記回折格子は前記平凹レンズの平面に形成されていることを特徴とする。

【００１３】本発明の光ピックアップにおいては、前記回折光学素子は、異方性光学材料からなる透光性平行平板上に形成された前記回折格子と、前記回折格子に充填された等方性光学材料からなる相補的透光性平行平板と、からなり、前記第１、第２及び第３光ビームのうちの１つの光の主要な偏光面を他の光の主要な偏光面に対して傾斜させる手段を有し、前記第１又は第２光ビーム照射時には有効開口を提供しかつ、前記第３光ビーム照射時には前記有効開口より小なる有効開口を提供する開口制御手段を備えたことを特徴とする。

【００１４】本発明の光ピックアップにおいては、前記回折光学素子は前記集光レンズ側に凹部を向けた平凹レンズを有していることを特徴とする。本発明の光ピックアップにおいては、前記回折光学素子は前記集光レンズ側の前記相補的透光性平行平板と一体化され前記集光レンズ側に凹部を向けた平凹レンズを有することを特徴とする。

【００１５】本発明の光ピックアップにおいては、前記開口制御手段はダイクロイックミラーであることを特徴とする。本発明の光ピックアップにおいては、前記第１、第２及び第３光ビームのうちの１つの光の主要な偏光面を他の光の主要な偏光面に対して傾斜させる角度は９０度であることを特徴とする。

【００１６】本発明の光ピックアップにおいては、前記異方性光学材料は一軸結晶であり、その光学軸が前記第１、第２及び第３光ビームの入射方向に対し傾斜していることを特徴とする。本発明の光ピックアップにおいては、前記回折光学素子は前記第１又は第２光ビームに対し凹レンズ作用をなすことを特徴とする。

【００１７】本発明の光ピックアップにおいては、前記集光レンズは、第１及び第２光ビームの波長範囲で収差が補正されたレンズであることを特徴とする。本発明の光ピックアップにおいては、前記回折格子は、前記集光レンズを介して、前記第１光ビームについては第１回折次数の第１光ビーム回折光を情報読取光又は情報記録光として集光し、前記第２光ビームについては前記第１回折次数より低次の第２回折次数の第２光ビーム回折光を情報読取光又は情報記録光として集光することを特徴とする。

【００１８】本発明の光ピックアップにおいては、前記第１光ビーム回折光が２次回折光であるとき前記第２光ビーム回折光は１次回折光であることを特徴とする。本発明の光ピックアップにおいては、前記回折格子の断面が鋸歯状又は階段形状の凹凸からなることを特徴とする。

【００１９】

【作用】本発明で使う液晶ホログラムは、アクティブな素子であり印可電圧の操作による切り替えが比較的簡単にできる。また、印可電圧の微調により、回折効率を常に最大に維持するサーボ動作も可能である。一方の偏光ホログラムはレーザの偏光方向を直交させることによって、切り替え動作を擬似的に代用させることができる。

【００２０】

【発明の実施の形態】以下、本発明の実施の形態を図面を参照しつつ説明する。

（光ピックアップ）図１は一例の形態の光ピックアップの概略を示す。光ピックアップは、第１波長が４００ｎｍ～４１０ｎｍ好ましくは４０５ｎｍ付近の短波長の青を出射するＨＤ－ＤＶＤ用半導体レーザＬＤ１と、第１波長より長い第２波長すなわち６３０ｎｍ～６６０ｎｍ好ましくは６５０ｎｍ付近のＤＶＤ用の中波長の赤を出射するＤＶＤ用半導体レーザＬＤ２と、第２波長より長い第３波長すなわち７８０ｎｍ付近のＣＤ、ＣＤ－Ｒ用の長波長の赤外を出射するＣＤ、ＣＤ－Ｒ用半導体レーザＬＤ３と、を備えている。この実施の形態では、ＤＶＤ用の赤のＤＶＤ用半導体レーザＬＤ２と、ＣＤ、ＣＤ－Ｒ用の赤外のＤＶＤ用半導体レーザＬＤ３とが一体型の半導体レーザを用いている。半導体レーザＬＤ１、ＬＤ２及びＬＤ３はそれぞれＣＤ、ＣＤ－Ｒ用、ＨＤ－ＤＶＤ用及びＤＶＤ用として切り替えて点灯される。

【００２１】さらに光ピックアップは、これら第１、第２及び第３の光ビームすなわち青、赤及び赤外の光路を共通化させる光軸結合素子の光軸結合プリズム（色合成プリズム）１０を備えている。この光学系の光軸結合プリズム１０は、図１に示すように、半導体レーザＬＤ１、ＬＤ２及びＬＤ３の発散光ビームを共通の光路となすように設計され、３つの波長のレーザビームの光軸を略一致させる機能を有する。光軸結合プリズム１０中のダイクロイックミラー１１は波長４０５ｎｍの青を反射する一方で、波長６５０ｎｍの赤及び波長７８０ｎｍの赤外を透過する特性を有しておりかつ、入射角度依存性を持つように多層誘電体薄膜により形成されている。ま

た、光軸を合成する光軸結合素子は、光軸結合プリズムに限定されることなく、ダイクロイックミラーに代えて、回折角の波長差を使った回折格子、液晶コレステリック層などを、光軸結合素子に用いることができる。

【0022】また光ピックアップは、光軸結合プリズム１０の光軸の下流に偏光ビームスプリッタ１３、コリメータレンズ１４及び対物レンズユニット１６を備えている。対物レンズユニット１６に１／４波長板１５も含まれている。以上の光照射光学系によって、第１、第２及び第３の半導体レーザＬＤ１、ＬＤ２及びＬＤ３の少なくとも一つからのレーザビームは、光軸結合プリズム１０及び偏光ビームスプリッタ１３を経て、コリメータレンズ１４で平行光ビームにされ、対物レンズユニット１６によって、その焦点付近に置かれている光ディスク５に向けて集光され、光ディスク５の情報記録面のピット列上で光スポットを形成する。すなわち、図１に示すように、レーザ光源ＬＤ１、ＬＤ２及びＬＤ３の３つの光源からの青、赤及び赤外の光ビームが光軸結合プリズム１０によって１光路に合成されているので、対物レンズユニット１６は、ＣＤ、ＣＤ－Ｒ、ＨＤ－ＤＶＤ及びＤＶＤのいずれかの光ディスクの記録面上に対応する青、赤又は赤外のいずれかを集光させる。

【0023】以上の光照射光学系に加えて、光ピックアップはさらに検出レンズ１７など光検出光学系を有しており、対物レンズユニット１６、１／４波長板１５及び偏光ビームスプリッタ１３は光検出光学系にも利用されている。ＣＤ、ＣＤ－Ｒ、ＨＤ－ＤＶＤ及びＤＶＤの何れか１つの光ディスク５からの反射光は、対物レンズユニット１６で集められ、１／４波長板１５を介して偏光ビームスプリッタ１３によって検出用集光レンズ１７に向けられる。検出レンズ１７で集光された集束光は、例えば、シリンドリカルレンズ、マルチレンズなどの非点収差発生素子（図示せず）を通過して、例えば、直交する２線分によって４分割されてなる４つの受光面を有する４分割光検出器の受光面２０中心付近に光スポットを形成する。

【0024】また、光検出器の受光面２０は復調回路を含むコントローラ３０及びエラー検出回路３１に接続されている。エラー検出回路３１は対物レンズユニットのトラッキング制御及びフォーカス制御用のアクチュエータ２６を含む機構を駆動する駆動回路３３に接続されている。４分割光検出器は、その受光面２０中心付近に結像された光スポット像に応じた電気信号をコントローラ３０及びエラー検出回路３１に供給する。コントローラ３０の復調回路は、その電気信号に基づいて記録信号を生成する。エラー検出回路３１は、その電気信号に基づいてフォーカスエラー信号や、トラッキングエラー信号や、その他サーボ信号などを生成し、アクチュエータの駆動回路３３を介して各駆動信号を各アクチュエータに供給し、これらが各駆動信号に応じて対物レンズユニット１６などをサーボ制御駆動する。

（対物レンズユニット）対物レンズユニット１６は、図１に示すように、光ビームを光ディスク記録面へ集光する集光レンズ１６ａと、電気で制御できる液晶層を備えた回折光学素子１６ｂと、を組み合せた複合対物レンズの組立体である。集光レンズ１６ａ及び回折光学素子１６ｂは、ホルダ１６ｃによって光路中心に同軸に配置される。

【0025】集光レンズ１６ａは、青の波長範囲４００ｎｍ～４１０ｎｍ又は赤の波長範囲６３０ｎｍ～６６０ｎｍで、又は少なくとも青の波長範囲で収差が補正された非球面レンズを用いる。集光レンズ１６ａは、青と赤の両波長範囲で収差が補正されたレンズを使うことがさらに望ましい。理由は赤と青の両波長での公差が緩くできるからである。一般的に、収差は波長で正規化され波長に反比例して公差が厳しくなるので、赤と青の波長で比べると、青の波長での望ましい特性を出す方が難しくなるので、特に、青の波長範囲で収差が補正された非球面レンズを使うことが望ましい。両波長で補正されている集光レンズとしては、通常の単一光学ガラスレンズが用いられ、更に、フォトポリマーいわゆる２Ｐを用いた２Ｐ法で作成された２Ｐ対物レンズなどが用いられる。

【0026】光源側すなわち光軸結合プリズム１０から集光レンズ１６ａまでの光路中に位置する回折光学素子１６ｂは、図２に示すように、一対の平行に対向したガラスなどの透光性の平板１６１、１６２と、これら平板に挟まれた液晶層１６３と、平板の対向する内面にそれぞれ設けられ液晶層に電圧を印加する一対の対向透明電極１６４、１６５と、その一方の平板の液晶層に面した内面上に設けられた回折格子１６ｅ（DOE: diffractive optical element）と、からなる。回折光学素子１６ｂの平板１６１、１６２の内側にある透明電極層１６４、１６５はＩＴＯ等により形成される。電極１６５は内側と外側で分割されている。この液晶制御用の透明電極は電極分割線で内外に二分割され、ＣＤ再生時にＮＡを制限する目的で使われる。分割線の半径はＣＤ再生に必要なＮＡ（通常０．４５程度）で決まり、ＤＶＤ再生のＮＡ０．６との比で、対物レンズ有効径の３／４程度で分割するのが好ましい。

【0027】液晶に接触している回折格子１６ｅは図２に示すように、光路の中心に配置された回転対称中心軸を有するパターンで形成され、光軸を中心に複数本の同心円に切削され又はホトリソグラフィにより積層された環状溝又は凸の輪帯すなわち、複数の凹凸からなるフレネルレンズ又はホログラムレンズを有する。回折格子１６ｅは、図３に示すように、その断面がブレーズ形状すなわち鋸歯状、又は、図４に示すように、階段形状となるように形成される。例えば、鋸歯状断面の回折格子は回折効率が他より高いので有利である。

【0028】回折格子１６ｅは、ＨＤ－ＤＶＤ又はＤＶ

Dの再生に必要な集光スポット径を実現するために必要な集光レンズ１６ａの開口数に相当する半径領域に同心円のホログラムパターン状で形成されている。また、回折格子１６ｅのホログラムパターンは、青又は赤の半導体レーザから出射し、コリメートレンズ１４など光学部品を透過した後に回折光学素子１６ｂに入射した光と、HD－DVD又はDVDの記録層で反射された後に集光レンズ１６ａを透過し、回折光学素子１６ｂに入射した光を回折格子を形成する面上で干渉させたときの干渉パターンと同じである。すなわち、回折格子のホログラムパターンは、１次回折光が生じたときに、光が対物レンズ５とHD－DVD又はDVDのディスク基板を透過することにより発生する球面収差を打ち消すような収差を有するように、設定される。

【００２９】回折格子１６ｅは、青又は赤に対し凹レンズ作用をなすように、設計されている。さらに、回折格子１６ｅは、集光レンズ１６ａを介して、青及び赤については１次以上の回折光を情報読取光又は情報記録光として集光し、赤外についてはゼロ次の回折光を情報読取光又は情報記録光として集光せしめるように、設計されている。

【００３０】鋸歯又は階段断面形状の回折格子１６ｅの作成法として、フォトリソグラフィ技術を応用する方法、ダイヤモンドバイトなどで精密切削する方法がある。これらによって、擬似的にブレーズを形成した多段階ブレーズ又はブレーズ形状の回折格子が透明電極上に形成できる。多段階ブレーズ又はブレーズ形状を金型に雛形を形成しておき、射出成形又はいわゆる２Ｐ法で透明プラスチック材料から回折格子を複製することもできる。回折格子１６ｅの断面形状は矩形でもよく、その断面が平坦板状で屈折率が周期的変化する構造でもよい。

【００３１】このように、同心円状のパターンの回折格子１６ｅを有する回折光学素子のピッチＰは設計値によって定められる。回折格子のピッチが細かくなるほど、収差の波長依存性は向上するが、ピッチが波長の５倍以下になると、原理的に回折効率が大きく低下する。また、ピッチが細かいほど形状ずれによる影響が大きくなる。そこで本実施の形態では、ピッチ１μｍの形状ずれが５％に相当する値として、２０μｍ以上を望ましい値とする。また、回折光学素子のピッチは、凹レンズの形状と組み合せた結果として、青と赤の波長に対して色収差が補正される条件と、ＣＤ再生時の赤外の波長に対して収差が補正される条件と、ディスク基板厚の０．６ｍｍから１．２ｍへの違いを補正する条件とを満たすように設計されている。ＣＤ再生時のＮＡを変えるためには上記内側及び外側電極にて内外周での印可電圧の調整で行なう。

【００３２】回折格子のブレーズの深さは以下のように決める。液晶の屈折率をｎｌｃとし、ブレーズを形成している母材の屈折率をｎとする。使用する光源の波長をλとしたときM次回折光が（Mは整数）最大になる深さＬは次式を満たすとき、最大の値となる。

【００３３】

【数１】 $L=M\cdot\lambda/(nlc-n)$

従って、各波長で上記式を満たすように、Ｌ、Ｍ、ｎ、ｎｌｃを定める必要がある。ここで液晶の屈折率ｎｌｃは、与える印可電圧によって変化し、その最大値ｎ‖（液晶分子の長軸方向と平行）と最小値ｎ⊥（液晶長軸と垂直）の間の値をとれる。以上のことを踏まえて、実際の数値を入れて計算する。

【００３４】青と赤は１次回折光、赤外は０次回折光、ブレーズ母材として屈折率およそｎ＝１．５のフォトポリマーいわゆる２Ｐを用い、液晶材料としてはメルク社のＺＬＩ－５０４９（ｎｌｃ＝１．５～１．７）を使えば、HD－DVDの場合はλ＝０．４μｍ、Ｍ＝１、ｎ＝１．５、ｎｌｃ＝１．７なので、Ｌ＝２μｍとなり、ＤＶＤの場合はλ＝０．６５μｍ、Ｍ＝１、ｎ＝１．５、ｎｌｃ＝１．７なので、Ｌ＝３．２５μｍとなる。ＣＤの場合はλ＝０．７８μｍ、Ｍ＝０、ｎ＝１．５、ｎｌｃ＝１．５となる。

【００３５】このことから、ブレーズ深さＬは最も厚いＤＶＤのＬ＝３．２５μｍに設定すれば良く、HD－DVDの波長０．４μｍに対してはｎｌｃの値を１．６２３にすれば上記式を満足する。図２の回折光学素子１６ｂの構成において、液晶層の膜厚は上記Ｌより厚いことが当然必要で、５～２０μｍ程度の膜厚に設定する。ガラス平板の基板の膜厚は通常０．７ｍｍ～１．１ｍｍが使われる。

【００３６】図２に示すように、回折格子１６ｅ下の分割されている対向電極１６５は、回折格子の回転対称中心軸に配置された中央透明電極１６５ａと、その周り配置された環状透明電極１６５ｂと、からなる。透明電極１６４、１６５各々の膜厚は透明電極自身で光が回折しないような膜厚に設定されている。中央及び環状の透明電極１６５ａ、１６５ｂは、これらへ独立して電圧を印加する電圧制御回路１６８すなわち電圧制御手段に接続されている。回折光学素子の光路長差を、青と赤と赤外の波長の必要な回折次数に対してそれぞれ高い回折効率が得られるように、液晶に適切な電圧を与える。必要な回折次数は例えば、青と赤に対しては０次回折光以外、赤外に対しては０次回折光である。

【００３７】図２に示すように、回折光学素子１６ｂは光路を共通にした平凹レンズ１７０を有している。図２では平凹レンズ１７０は回折光学素子１６ｂの光学的下流に配置され集光レンズ１６ａ側に凹部を向けているが、図１９に示すように、素子の液晶を制御する電極１６５ａ及び１６５ｂ並びに回折格子１６ｅを光学的上流側の透光性平板１６１上に設けて、平凹レンズ１７０が回折光学素子１６ｂの光学的上流において光源側に凹部を向けて配置されることも好ましい。凹レンズ１７０は

通常、単レンズで、凹面は球面または非球面で形成される。もう片方の面は、球面であっても良いが製作上は平面の方が簡便である。凹レンズ１７０は通常、液晶回折光学素子と別に配置されるが、図２に示したように液晶の平板基板と接着することができる。また、部品数を減らすために、図５に示したように凹レンズ１７１が液晶のガラス基板を兼用するように構成することもできる。図５では一体化された凹レンズ１７１は回折光学素子１６ｂの光学的下流側に位置し集光レンズ１６ａ側にその凹部を向けているが、図１９の構成と同様にして、図２０に示すように、回折光学素子１６ｂの光学的上流側に位置して光源側に凹部を向けて素子の透光性基板と一体化することもできる。回折光学素子１６ｂの基板を凹レンズにすることは、最良像点を固定した集光レンズ１６ａの特性に対し、波長依存特性が凹レンズで改善し反対に凸レンズで劣化となる影響が生じるからである。

【００３８】さらに、図６に示すように液晶回折光学素子１６ｂの透光性の平板１６１の光源側表面にコリメータレンズ１４を配置することも可能である。そのような設計にすれば、集光レンズ１６ａ側凹レンズを省くことができる。上記のレンズ系と回折光学素子の設計は３波長のそれぞれの条件において、集光レンズを含めて性能を満足するように定める。その理由は、集光レンズと回折光学素子の合成のパワーを、どちらかの波長でほぼ０とすることができ、位置精度などの公差を緩くすることができるからである。さらに、使う回折光学素子の回折次数はそれに合わせて設定する。例えば、通常の光学ガラスの集光レンズの時は、赤と青が１次回折光、赤外が０次回折光の組み合わせ、或いは青２次回折光、赤１次回折光、赤外０次回折光などの組み合わせが可能である。また、上記の２Ｐ対物レンズを使う場合は、赤青が０次回折光、赤外０次回折光の組み合せが可能である。更に、プラス回折次数の回折光の他にマイナス回折次数の回折光を使うこともできる。

【００３９】回折光学素子１６ｂは中央透明電極１６５ａ及びその外側に形成された環状透明電極１６５ｂと透明電極１６４との間に液晶層１６３を挟んだ構造であるので、電極１６５ａと透明電極１６４と間若しくは電極１６５ｂと透明電極１６４と間に独立に電圧を印加すると、電圧印加形態により、回折光学素子１６ｂは次の２つの機能を果たす。

【００４０】図７に示すように、回折光学素子１６ｂは、両電極１６５ａ、１６５ｂに同一電圧を印加することによって、液晶層１６３が中央透明電極１６５ａの外側と内側を透過する光の偏光方向を等しくする機能を有する。さらに、図８に示すように、両電極１６５ａ、１６５ｂに異なる電圧を印加することによって、液晶層１６３が中央透明電極１６５ａの外側を透過する光の偏光方向を中央透明電極１６５ａを透過する光の偏光方向に対して９０°回転する機能を、回折光学素子１６ｂは有している。したがって、２つの電極１６５ａ、１６５ｂへ電圧印加することにより、集光レンズ１６ａの実効的な開口数を変化させることができる。電圧制御回路１６８は青又は赤の照射時には中央透明電極１６５ａ及び環状透明電極１６５ｂに同一電圧を印加し、赤外の照射時には両電極１６５ａ、１６５ｂに異なる電圧を印加する制御をなす。それにより、回折光学素子１６ｂは内周では赤外の０次回折光の効率が高く、外周では低くして、ＮＡを制限する効果を発揮する。

【００４１】次に、回折光学素子１６ｂの動作について説明する。図１に示すように、光ディスクが装置に装填された時には、光ディスクの種類を識別する手段（図示せず）によって、光ディスクの種類を識別し、その結果、識別信号がコントローラ３０へ供給される。装填光ディスクに応じてコントローラ３０が電圧制御回路１６８を駆動し、あらかじめ設定された液晶動作電圧を中央透明電極１６５ａと環状透明電極１６５ｂを介して液晶層１６３に印可する。

【００４２】この他に、液晶印可電圧の設定誤差や周囲温度により、最適印可電圧からずれている場合は、検出器の受光面２０の受光光量が常に最大になるようにサーボ動作をすれば良い。ＣＤ或いはＣＤ－Ｒ再生時には内外周の中央透明電極１６５ａと環状透明電極１６５ｂに与える印可電圧を、所定の回折次数に対して内周は最大効率、外周は最小の効率になるように設定する。これも、検出器の受光面２０からのＲＦ信号やジッタを常に最適にするようなサーボ動作させることで実現できる。

【００４３】このような機能を有する光ピックアップとして、例えば、回折格子が青（４０５nm）に対しては１次回折光、赤（６５０nm）に対しては１次回折光、赤外（７８０nm）に対しては０次回折光を使った回折光学素子を、回転対称体として設計した対物レンズユニットを含む光ピックアップを作製した。光ディスクの条件は青の４０５nmではNA＝０．６１でディスク基板厚０．６mmであり、赤の６５０nmではNA＝０．６０でディスク基板厚０．６mmであり、赤外の７８０nmではNA＝０．４５でディスク基板厚１．２mmである。

【００４４】非球面の集光レンズの光源側に平凹のレンズの回折光学素子が配置され、その凹面上に回折格子を形成し、凹面及び回折格子はいずれも非球面形状とした。よって、第１面及び第２面は回折光学素子の入射面及び出射面であり、第３面及び第４面は集光レンズの入射面及び出射面である。各非球面Ｚは次式数２で表される。

【００４５】

【数２】

$$Z=\frac{(1/R)r^2}{1+\sqrt{1-(1/R)^2(K+1)r^2}}+\sum_i ASir^i$$

【００４６】（但し、Ｚ：ＳＡＧ量、Ｒ：曲率半径、Ｋ：円錐係数、ｒ：光軸からの半径、ＡＳｉ：非球面係数）＊

＊位相関数Φ（ｒ）は、は次式数３で表される。

【００４７】

【数３】

$$\Phi(r)=dor\frac{2\pi}{\lambda_0}(DF0+DF1r^2+DF2r^4+DF3r^6+DF4r^8+DF5r^{10})$$

【００４８】（但し、dor：回折次数、λ_0：波長、ｒ：光軸からの半径、ＤＦ１～ＤＦ５：係数）

自動設計された各非球面レンズのデータは表１～３のと※

※おりである。

【００４９】

【表１】

	面番号	曲率半径	面間隔	屈折率
回折光学素子	1	−44.000000	1.000000	1.605256
	2	—	0.300000	
集光レンズ	3	2.161300	1.798000	1.605256
	4	−17.079390	1.000000	
ディスク	5	—	0.600000	1.621082
	6	—	0.878702 V	

【００５０】★

★【表２】

		第１面	第３面	第４面
非球面係数	AS2	0.000901	−0.000738	0.008569
	AS3	−0.000189	−0.000211	−0.003385
	AS4	7.7143e−05	−0.000123	0.000760
	AS5	−2.3508e−06	2.9546e−06	−6.4927e−05
円錐係数　(K)		325.035360	−0.418560	17.362981

【００５１】

【表３】

	第１面
DF0	−0.000200
DF1	−0.003646
DF2	0.000172
DF3	−0.000103
DF4	3.2853e−05
DF5	−2.2250e−06

【００５２】図９に、得られた対物レンズユニットのＨＤ－ＤＶＤ（光ディスク厚み０．６ｍｍ、光源波長λ=４０５±５ｎｍ）に対する波面収差の変化Ａ、ＤＶＤ（光ディスク厚み０．６ｍｍ、光源波長λ=６５０±１０ｎｍ）に対する波面収差の変化Ｂ、ＣＤ（光ディスク厚み１．２ｍｍ、光源波長λ=７８０±１０ｎｍ）に対する波面収差の変化Ｃを示す。図９において横軸に波長、縦軸に光軸上での波面収差量（rms（λ））をとった波長依存性を示す。図示するように対物レンズユニットの波面収差はいずれの波長においてもマレシャル限界０．０７λ以下に抑えられている。

【００５３】このように、本発明の回折格子は、集光レンズを介して、青及び赤については絶対値が１次以上の回折光を情報読取光又は情報記録光として集光し、赤外についてはゼロ次の回折光を情報読取光又は情報記録光として集光せしめるように、設計されるが、更に、回折格子は、青については高い回折次数の第１光ビーム回折光を情報読取光又は情報記録光として集光し、赤についてはその高い回折次数より低次の回折次数の第２光ビーム回折光を情報読取光又は情報記録光として集光するように、設計され得る。

【００５４】例えば、回折光学素子１６ｂの回折格子１６ｅは、図１０に示すように、波長４０５ｎｍの青色の第１光ビームが透過するとき、その２次の回折光Ｂ２を、情報読取光又は情報記録光として集光レンズ１６ａを介してＨＤ－ＤＶＤディスク記録面上に集光するように、形成されるとともに、同時に回折格子１６ｅは、図１１に示すように、波長６５０ｎｍの赤色の第２光ビームが透過するとき、第１光ビーム回折光の２次回折光より低次の１次回折光Ｒ１を、情報読取光又は情報記録光として対物レンズを介してＤＶＤディスク記録面上に集光するように、形成される。これら場合、赤の０次回折光Ｒ０及び高次回折光並びに青の０次及び１次回折光Ｂ０及びＢ１はディスク記録面上に合焦状態にないので、これら回折光は読取又は記録にはほとんど影響しない。上記例では光源の第１及び第２光ビームすなわち赤と青の半導体レーザの波長範囲はそれぞれ赤（６３０～６６

0nm)、青(400〜410nm)としているが、この範囲であれば回折効率が大きく変化することがないからである。さらに、第1光ビーム回折光の第1回折次数は、第2光ビーム回折光の第2回折次数より1だけ大きく、かつ第2光ビーム回折光の第2回折次数は1以上であることが好ましい。よって、第1光ビーム回折光が2次回折光であるとき第2光ビーム回折光は1次回折光である上記の例の他に、HD−DVD用に波長405nmの3次回折光を第1光ビーム回折光に用いたときDVD用に波長650nmの第2光ビーム回折光として2次回折光が集光されるように、回折光学素子16bの回折格子16eは作製され得る。

【0055】この実施形態では赤外に対し0次の回折光すなわちパワーを持たない回折格子を用い、赤と青の0次の回折光を用いずに、青の2次の回折光を用い、赤では2次より1つ低次の1次回折光を用いるように、回折格子は形成されている。すなわち、本発明の回折格子は、その光路長差を、赤と青の波長の必要な回折次数に対してそれぞれ高い回折光率が得られるように形成されている。

【0056】例えば、ブレーズ断面形状の回折格子を、ピッチPを160〜260μmとして、回折格子の深さdを0〜3μmに変化させて、基材として例えばOZ−1000(日立化成)のプラスチック材料からなる回折光学素子を作製した場合の、回折格子の回折効率の変化を算出してみる。実施の形態における回折格子は、そのピッチが波長より十分長いのでスカラー理論が適用でき、また、その深さが波長程度なのでいわゆる薄膜グレーティングとして扱える。その場合、回折効率ηmは次式数1で表される(mは回折次数)。

【0057】

【数4】

$$\eta m=\left|\frac{1}{T}\int_0^T A(x)\exp\{i\varphi(x)\}\exp\left(-i\frac{2\pi mx}{T}\right)dx\right|^2$$

【0058】式中、A(x)は透過振幅分布、φ(x)は位相分布、Tはグレーティングのピッチを示している。計算においてはA(x)=1として規格化している。また、回折格子のピッチについて一般にピッチが細かくなるほど、収差の波長依存性は向上するが、ピッチが波長の5倍以下になると、原理的に回折効率が大きく低下する。また、ピッチが細かいほど形状ずれによる影響が大きくなる。そこで本実施の形態では、ピッチ1μmの形状ずれが5%に相当する値として、20μm以上を望ましい値とする。

【0059】図12は、横軸に回折格子の深さd、縦軸に回折格子の回折効率の変化を算出した結果である。図中の"B0"、"B1"、"B2"、"B3"はそれぞれ青の0次回折光、1次回折光、2次回折光、3次回折光の回折効率を、"R0"、"R1"、"R2"はそれぞれ赤の0次回折光、1次回折光、2次回折光の回折効率を示す。

【0060】図12から明らかなように、ブレーズ化した回折格子は位相深さが光の1波長λ毎の周期で回折効率が最大値をとる。回折格子の位相深さは、dを実際の回折格子の深さ、nを回折光学素子基材の屈折率とすると、これらの積d(n−1)で表される。波長λ=405nmに対し基材材料の屈折率n_B=1.531で、波長λ=650nmに対し同屈折率n_R=1.498であるので、これから計算すると405nmで位相差が1波長λになる回折格子の深さは0.763μmで、この深さで青の1次回折光の回折効率が最大になる。青の2次回折光はその倍の1.526μm、同様に赤の1次回折光は1.305μmで最大となる。

【0061】これらのことから、赤と青のいずれの波長でも高い回折光率が得られる回折格子の深さは、R1とB2の交点、R2とB3の交点であることが分かる。つまり第1波長の青の2次回折光B2及び第2波長の赤の1次回折光R1で使う1.42μm付近と、青の3次回折光B3及び赤の2次回折光R2で使う2.4μm付近が、高回折光率が得られる回折格子の深さである。回折格子の深さは0.2μmずれると十数%位の効率減少になるので、これ以上を確保するためには、高回折光率が得られる回折格子の深さが、1.42±0.2μm又は2.40±0.2μmの範囲内とすることが好ましい。

【0062】また、図12から明らかなように、第1光の青の1次回折光B1及び第2波長の赤の1次回折光R1の交点(回折格子の深さは、0.965μm)においても、回折光率が80%程度と決して低くはないが、少しでも回折格子の深さにずれが生じると、回折効率が大きく低下する。青の2次及び3次回折光の回折効率のピークは深さ1.526μm及び2.289μmで、同様に赤の1次及び2次回折光では1.305μm及び2.610μmであるので、回折格子の深さにずれが生じても青及び赤の回折効率のピーク近傍の交点であれば、回折効率の変動が少ないが、それぞれのピークから離れる交点では大きく変動する。

【0063】本発明によれば、青のレーザー光源を使うHD−DVDと赤のレーザー光源を使うDVDと、更に、赤外線レーザ光源を使うCD及びCD−Rのそれぞれの情報再生が可能で、計3波長に対応して1個の対物レンズでコンパチビリティを可能にする光ピックアップを実現でき、対物レンズとして青又は赤の波長範囲で補正されたレンズを使う場合、はるかに緩和された設計が可能となる。

(第2の実施の形態)図13に示すように、上記実施形態の液晶装置を用いた回折光学素子16b及び電圧制御回路168に代えて、偏光素子を用いた偏光回折光学素子169を設けた以外、上記実施形態と同一の光ピックアップが構成され得る。また、この回折光学素子16は集光レンズ側に凹部を向けた平凹レンズを有している構

成としてもよい。さらに、回折光学素子は集光レンズ側の相補的透光性平行平板と一体化され集光レンズ側に凹部を向けた平凹レンズを有することもできる。

【００６４】図１４に示すように、かかる偏光回折光学素子１６９は、ニオブ酸リチウムなどの一軸結晶の異方性光学材料からなる平板の主面に上記の手法により設計した回折格子１６ｅの凹部を形成した異方性光学材料基板１６９ａと、光学ガラスなどの等方性材料からなるその凹部に充填した充填部１６９ｂとからなり、両主面を平行平面としたものである。異方性光学材料基板１６９ａが光源側には位置される。すなわち、回折光学素子は、異方性光学材料からなる透光性平行平板１６９ａ上に形成された回折格子１６ｅと、回折格子に充填された等方性光学材料からなる相補的透光性平行平板１６９ｂと、からなる。回折格子１６ｅは凹レンズとして作用しその断面は好ましくはブレーズ形状となるように、形成される。回折光学素子の光路長差を、青と赤の２波長の必要な次数に対してそれぞれ高い回折効率が得られるようにする。すなわち、回折格子の段差深さは赤と青の波長に対して効率の高い値に設定される。

【００６５】図１４に示すように、異方性光学材料基板１６９ａの光学軸を例えばその平面に沿った方向に配置すると、垂直に入射した光は図１５及び図１６に示すように、異常光と常光とが生じる。そこで、異方性光学材料基板１６９ａの常光における屈折率と等しい屈折率を有する等方性光学材料にて、相補的透光性平行平板１６９ｂを形成する。この場合、偏光回折光学素子に入射する赤と青の光の偏光方向が異方性光学材料基板１６９ａが作用する偏光方向と同一になし、かつ赤外光の偏光方向に対してはそれと直交する偏光方向を使う。すなわち、青、赤及び赤外の光ビームのうち赤外の主要な偏光面を他の光の主要な偏光面に対して例えば９０度傾斜させれば、図１５に示すように、青と赤の第１方位（紙面平行）に対しては回折光学素子として作用し、図１６に示すように、それと直交する赤外の第２方位（紙面垂直）は等方的となり単なるガラス平行平板と等価になる。なお、光ビームの入射方向と異方性光学材料基板１６９ａの光学軸とを平行にしなければ、異常光と常光とが生じるので、異方性光学材料の一軸結晶の光学軸が光ビームの入射方向に対し傾斜していればよい。

【００６６】このように、赤と青のレーザは第１の方位で入射し、赤外については第２の方位で入射させることにより、例えば、赤は１次回折光、青は２次回折光、赤外は０次回折光の回折光を使う条件が満たされるようになる。図１７に示すように、直交xyz座標にてz軸を入射方向として、x軸を異常光の偏光面、y軸を常光の偏光面と設定した場合、青と赤の光ビームの偏光面を赤外の光ビームの偏光面に対して傾斜させる手段としては、青と赤のＨＤ－ＤＶＤ用半導体レーザＬＤ１とＤＶＤ用半導体レーザＬＤ２を、それらのレーザ構造における接合面がx軸に平行になるように配置しかつ、図１８に示すように、赤外のＣＤ、ＣＤ－Ｒ用半導体レーザＬＤ３をその接合面がx軸に垂直即ちy軸に平行になるように配置すればよい。また、赤外のＣＤ、ＣＤ－Ｒ用半導体レーザＬＤ３だけの光路に波長板を挿入しても、レーザ光の偏光面を傾斜できる。

【００６７】また、上記の液晶回折光学素子のような電圧制御は不要であるが、開口制限はできないので、青又は赤の光ビーム照射時には有効開口を提供しかつ、赤外の光ビーム照射時には有効開口より小なる有効開口を提供する開口制御手段を備える。開口制御手段として例えば図１８に示すように、ＣＤ－Ｒ用半導体レーザＬＤ３だけの光路に第２のダイクロイックミラー２００を配置すれば比較的容易に実現できる。

【００６８】これにより、ＤＶＤ及びＨＤ－ＤＶＤ用のコンパチブルプレーヤの構造を極めて簡略化でき、ピックアップの小型化低コスト化が達成される。

【００６９】

【発明の効果】本発明によれば、光ピックアップにおける回折光学素子は、赤、青及び赤外の光源を備えかかつ回折格子を含む回折光学素子を備えた光ピックアップにおいて、集光レンズを介して、第１及び第２光ビームについては１次以上の回折光を情報読取光又は情報記録光として集光し、第３光ビームについてはゼロ次の回折光を情報読取光又は情報記録光として集光せしめる断面が鋸歯状又は階段形状の凹凸からなる回折格子を用いるので、対応波長の異なる光ディスク又は記録面に対し記録再生可能な小型化光ピックアップを得ることができる。

【図面の簡単な説明】

【図１】　本発明による実施形態の光ピックアップ内部の概略構成図である。

【図２】　本発明による光ピックアップにおける回折光学素子の部分切欠斜視図である。

【図３】　本発明による光ピックアップにおける回折格子の部分断面図である。

【図４】　本発明による光ピックアップにおける回折格子の部分断面図である。

【図５】　本発明による他の実施形態の光ピックアップにおける回折光学素子の部分切欠斜視図である。

【図６】　本発明による他の実施形態の光ピックアップにおける回折光学素子の部分切欠斜視図である。

【図７】　本発明による光ピックアップにおける対物レンズユニットの部分断面図である。

【図８】　本発明による光ピックアップにおける対物レンズユニットの部分断面図である。

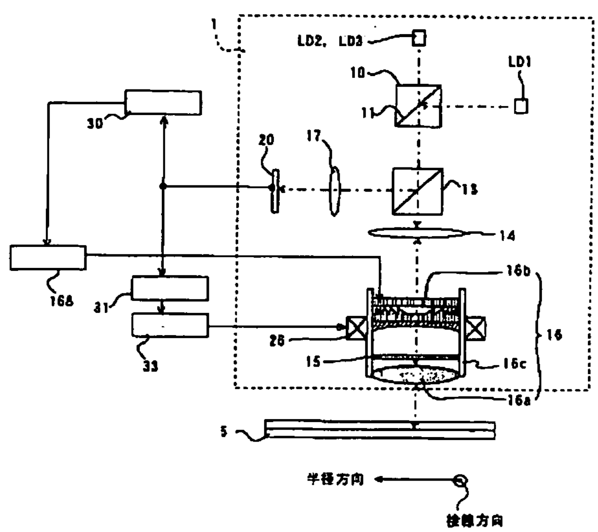
【図９】　対物レンズユニットの青及び赤の１次回折光並びに赤外の０次回折光に対する波面収差の変化を示すグラフである。

【図１０】　本発明による光ピックアップにおける対物レンズユニットの部分断面図である。

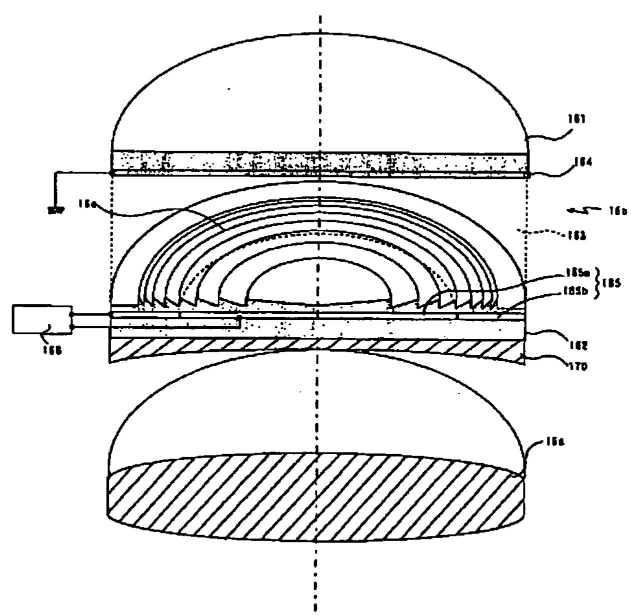
【図１１】　本発明による光ピックアップにおける対物レンズユニットの部分断面図である。
【図１２】　本発明による光ピックアップにおける対物レンズユニットの回折格子の深さと回折効率との関係を示すグラフである。
【図１３】　本発明による他の実施形態の光ピックアップ内部の概略構成図である。
【図１４】　本発明による他の実施形態の光ピックアップにおける回折光学素子の部分切欠斜視図である。
【図１５】　本発明による他の実施形態の光ピックアップにおける回折光学素子の部分断面図である。
【図１６】　本発明による他の実施形態の光ピックアップにおける回折光学素子の部分断面図である。
【図１７】　本発明による他の実施形態の光ピックアップにおける要部の概略部分斜視図である。
【図１８】　本発明による他の実施形態の光ピックアップにおける要部の概略部分斜視図である。
【図１９】　本発明による他の実施形態の光ピックアップにおける回折光学素子の概略部分切欠斜視図である。
【図２０】　本発明による他の実施形態の光ピックアップにおける回折光学素子の概略部分切欠斜視図である。

【符号の説明】
１　光ピックアップ
５　光ディスク
１０　光軸結合プリズム
１１　ダイクロイックミラー合成面
１３　偏光ビームスプリッタ
１４　コリメータレンズ
１５　１／４波長板
１６　対物レンズユニット
１６ａ　集光レンズ
１６ｂ　回折光学素子
１６ｃ　ホルダ
１６ｅ　回折格子
２０　光検出部受光面
２６　アクチュエータ
３０　コントローラ
３１　エラー検出回路
３３　駆動回路
ＬＤ１　第１半導体レーザ
ＬＤ２　第2半導体レーザ
ＬＤ３　第３半導体レーザ

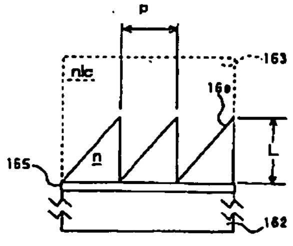
【図１】



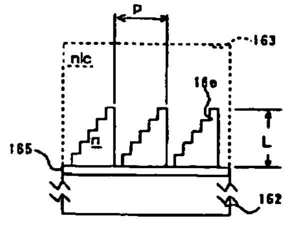
【図２】



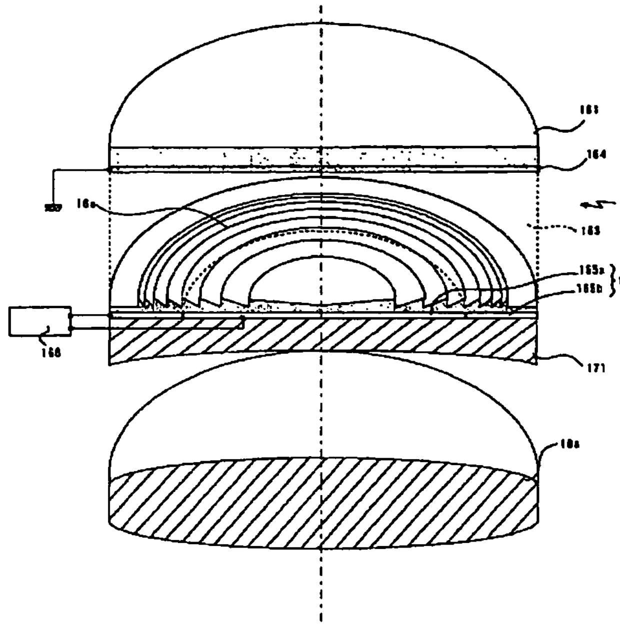
【図３】



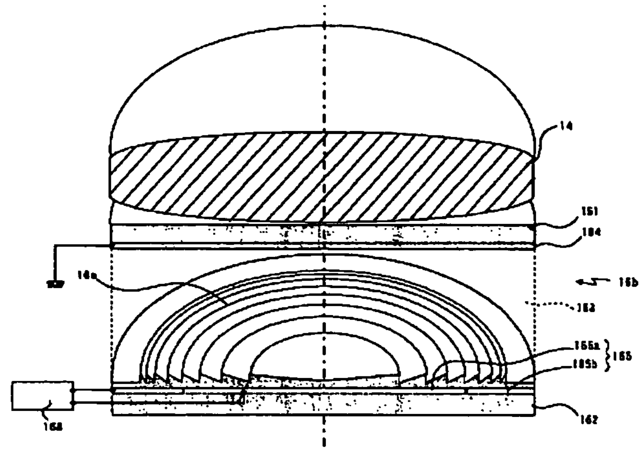
【図４】



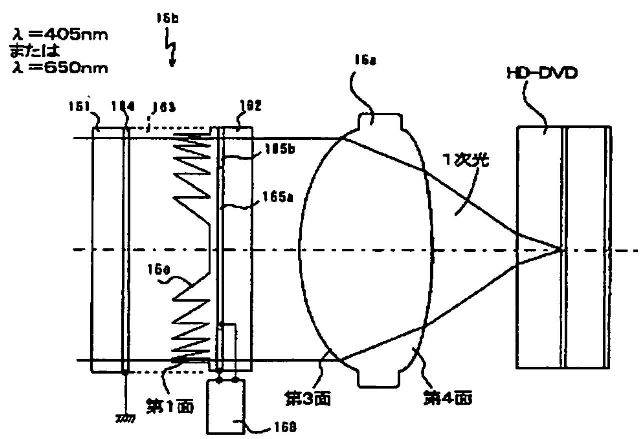
【図5】



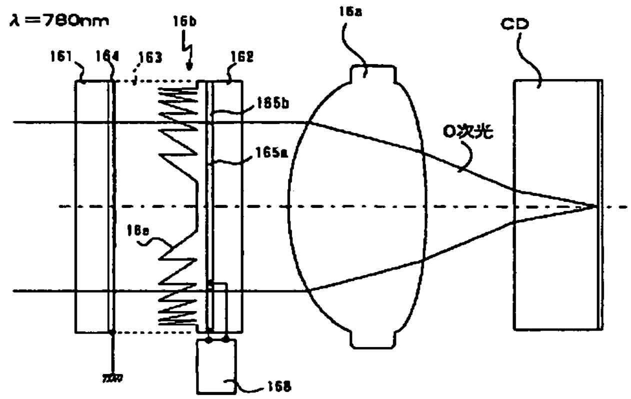
【図6】



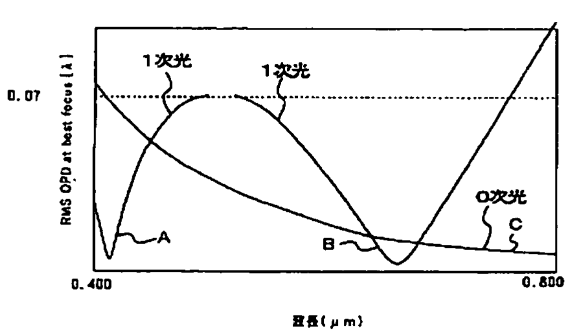
【図7】



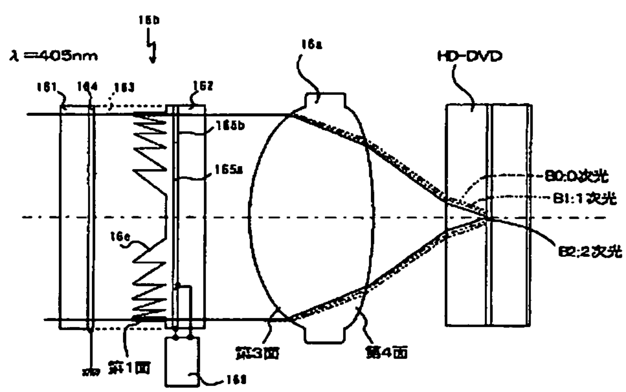
【図8】



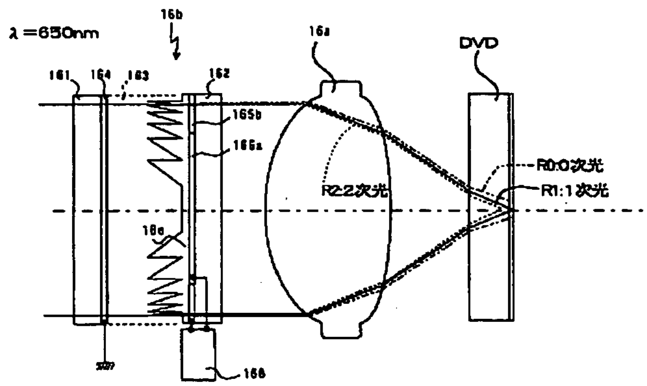
【図9】



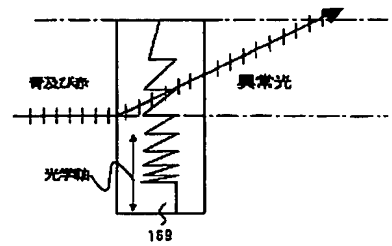
【図10】



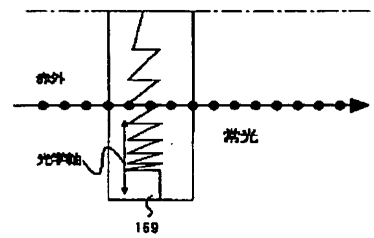
【図１１】



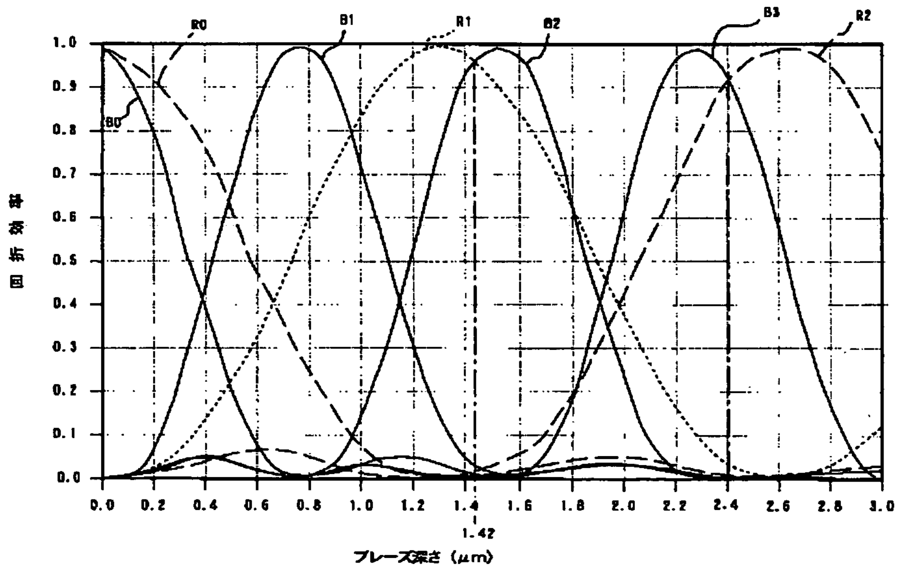
【図１５】



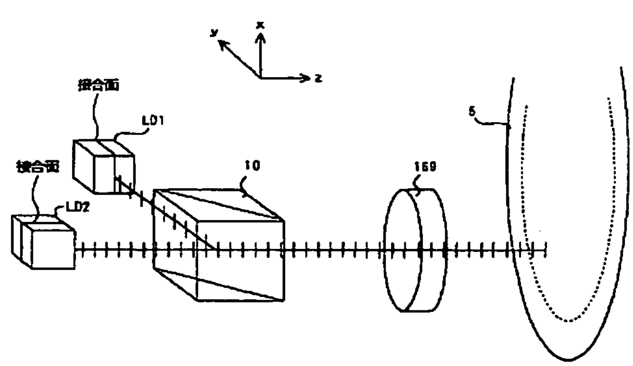
【図１６】



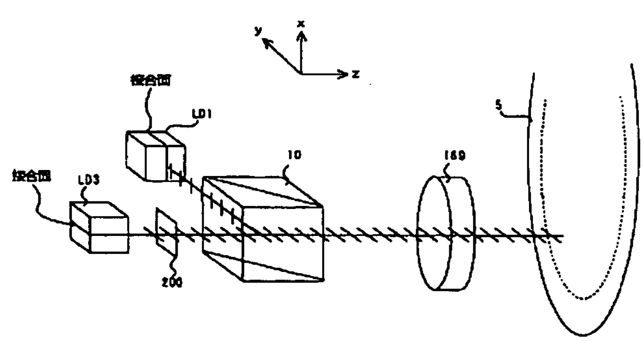
【図１２】



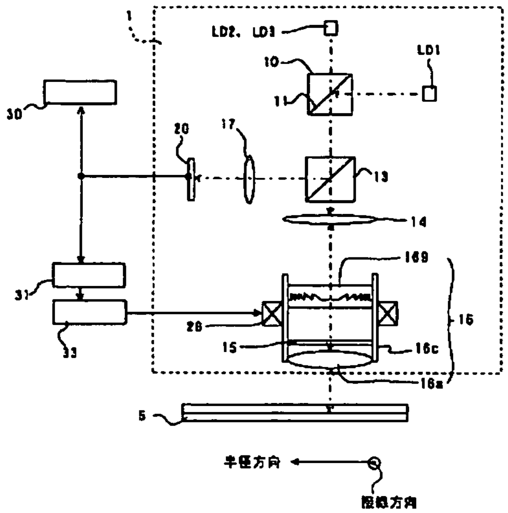
【図１７】



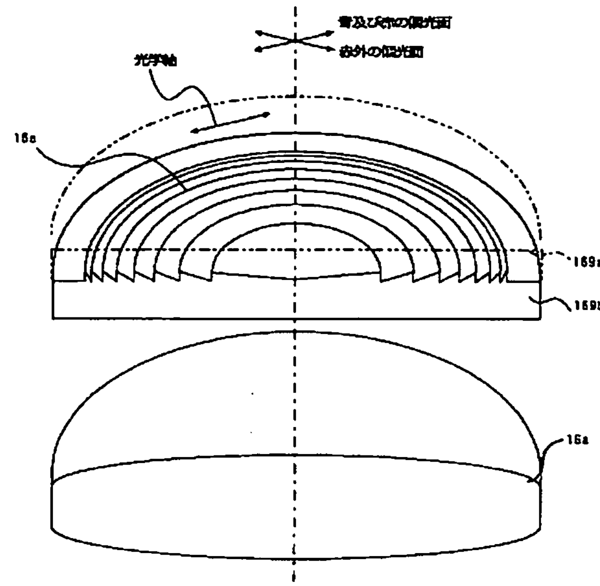
【図１８】



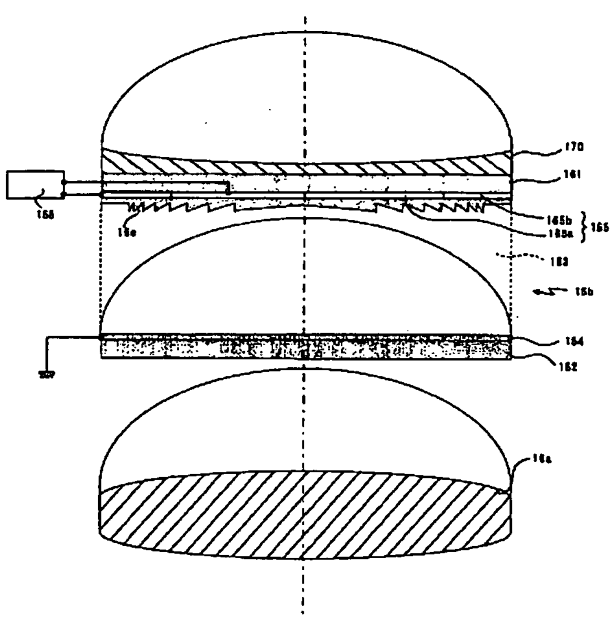
【図13】



【図14】



【図19】



【図20】